Gharyan Journal of Technolgy

Annual, Corrected and Accademic Journal

Issued By

Higher Institute of Sciences and Technology, Gharyan

Gharyan - Libya

Issue (9), July- 2023

International Code: ISSN (Print) 2518-5993

ISSN (Online) 2521-9308

www.gjt.scitech-gh.edu.ly

Gharyan Journal of Technology

Annual, Reviewed and Academic Journal

Issued By :

Higher Institute of Sciences and Technology, Gharyan

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Estimation the relations between porosity and permeability using core data

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الملخص

المسامية والنفاذية هي خصائص مرتبطة بأي صخر أو رواسب صخرية. كلاهما مرتبط بعدد وحجم ووصلات الفتحات في الصخر. وبشكل أكثر تحديدًا ، تعد مسامية الصخور مقياسًا لقدرتها على الاحتفاظ بالسوائل. رياضيا ، هو الفراغ المفتوح في الصخر مقسومة على الحجم الكلي للصخور (الصلبة و الفراغ). النفاذية هي مقياس لسهولة تدفق السائل عبر مادة صلبة مسامية. قد تكون الصخور مسامية للغاية ، ولكن إذا لم تكن المسام متصلة ، فلن يكون لها نفاذية. وبالمثل ، قد يحتوي الصخر على عدد قليل من الشقوق المستمرة التي تسمح بسهولة تدفق السوائل ، ولكن عند حساب المسامية ، لا يبدو الصخر مساميًا جدًا.

غالبًا ما يتم اختبار الارتباطات بين المسامية ، Φ ، والنفاذية ، k، للصخور الرسوبية فيما يتعلق بالجيولوجيا البترولية وخصائص الخزان. يمكن توقع اتجاه عام لزيادة النفاذية مع المسامية. ومع ذلك ، فإن تأثيرات حجم الحبيبات ، والتعبئة ، والضغط ، وعمليات إذابة المحلول المتعلقة بتطوير المسامية الأولية والثانوية أو الحفاظ عليها أو فقدها ، يمكن أن تؤدي إلى مجموعة متنوعة من العلاقات بين النفاذية وأشكال مختلفة من المسامية.

ABSTRACT

Porosity and permeability are related properties of any rock or loose sediment. Both are related to the number, size, and connections of openings in the rock. More specifically, porosity of a rock is a measure of its ability to hold a fluid. Mathematically, it is the open space in a rock divided by the total rock volume (solid and space). Permeability is a measure of the ease of flow of a fluid through a porous solid. A rock may be extremely porous, but if the pores are not connected, it will have no permeability. Likewise, a rock may have a few continuous cracks which allow ease of fluid flow, but when porosity is calculated, the rock doesn't seem very porous.

Correlations between porosity, Φ , and permeability, k, are often tested for sedimentary rocks in relation to petroleum geology and reservoir characterization. A general trend of increase in permeability with porosity can be expected. However, the effects of grain size, packing, compaction, and solution dissolution processes related to development, preservation or loss of primary and secondary porosity can lead to a wide variety of relationships between permeability and various forms of porosity

Keywords: porosity , Reservoir permeability

INTRODUCTION AND LITERATURE REVIEW

The main factor is the amount of space available between particles, sediments, and rocks in the soil layers and spaces between particles in rocks and rock layers. The amount of pore space in soil, sediments, and rock is called porosity, which can also be defined as the percentage of a material's total volume that is taken up by pores. This "empty" space has a fantastic ability to hold water that seeps down from the land surface. Material with good porosity can be called "porous". Mathematically, porosity can be expressed as the ratio of the volume of pore space to the total volume of the material as given by the following formula:

$$\% \text{ porosity} = \frac{\text{Volume of pore space}}{\text{Total volume of sediment}} \times 100$$

Porosity depends on the size, shape, and mixture of grains and particles that compose soil and rock. For instance, small particles such as clays are able to compact more closely together, reducing the amount of porosity. However, larger particles such as sand and gravel will have more spaces available between them. Round particles compacted together will have more spaces than elongated grains that stack more tightly. Particles of uniform size (well sorted) will also have more pore space available than grains of varying sizes (poorly sorted) because small particles can fill in the spaces between the larger grains. Porosity can change between various layers of soil and types of solid rock. [1]

In addition to porosity (the amount of pore space), permeability is another important factor needed for groundwater movement to occur. Permeability is the measure of how easily water flows through soil or rocks, so it depends on the size of the pore space and how well connected they are to one another. It is often defined as pore interconnected and the unit of measurement is usually distance (cm, m, or ft.) per time (second, minute, day). Permeability can also be referred to as hydraulic conductivity. Like porosity, permeability can also change between various soil layers and types of solid rocks.

Permeability depends on several factors – grains size of particles and the amount of cracks and fractures. If the sediments or rock particles are composed of very small grains, such as in clays and silts, the space through which water can flow is limited. In addition, clay particles have a lot of surface area to which hygroscopic water attaches, creating a further resistance to fluid movement. If sediments are comprised of coarser grains like sand and gravel, pore space is more available. These coarser grains also have less surface area, so less water can attach to them, allowing better fluid movement. With grains of many sizes, the permeability will be at medium rates. Fine sediments fill in spaces between larger particles, reducing poor space and increasing surface areas to which water can adhere.

For rocks composed of poorly sorted material or fine grains, water movement can be slow unless there are fractures and cracks in the rock. Along roadside rock cuts, it is common to observe groundwater seeping from cracks or forming icicles. Some rocks such as limestone and dolomite can form more than just cracks; water can actually dissolve them causing openings within the rocks to widen, possibly wide enough to become caves.

Sediments that have high porosity and permeability tend to form rocks with the same characteristics; for instance, sands form sandstones and clays form shales. [2]

Generally, the greater the porosity, the greater the permeability. Both of these factors are important to consider when determining how much groundwater is stored in our underground layers. If you needed to drill a well to find groundwater to drink, you would hope to find a good groundwater aquifer. It would probably be rock and sediment with high

porosity so that it can hold large amounts of water, and high permeability, so the water can be pumped and sucked through the layers easily.

Usually the larger the consolidated (well sorted) grain size, the better the porosity and permeability (aquarium gravel). If the materials are poorly sorted (lots of different sizes) then it reduces porosity and permeability because smaller grains fall between larger grains, reducing space and flow paths (gravel and sand; sand and clay mixture). Surprisingly, clay can have high porosity too because clay has a greater surface area than sand, therefore, more water can remain in the soil. However, clay has bad permeability. The connectedness between clay particles is low and clay tends to retain water (because of the greater surface area again), slowing gravitational flow downward.

Porosity has been classified by Lucia (1995) as antiparticle and vuggy. Antiparticle porosity includes intergraui and intercrystal porosities and correlates reasonably well with permeability. Porosity identified as vuggy, which may include separate vugs and fractures, does not correlate with permeability . Porosity of porous media is defined as,

$$\Phi = Vp / Vb$$

where Vp is the pore volume and Vb the bulk volume. Conceptually, if Vp = total pore volume, the porosity is the total porosity. If Vp = effective pore volume, the porosity is the effective porosity. Obviously, the effective porosity will correlate better with permeability than the total porosity. However, the difference between the total and effective porosities is generally very small for sedimentary rocks and will be neglected. [3]

For a core sample of bulk volume Vb porosity is proportional to the pore volume. Although all the pore bodies and their throats contribute to porosity, pore bodies of their size) is more Important role than the pore throats. [4]

]

Permeability is defined by Darcy 's law

$$K = \frac{q\mu L}{A\Delta P}$$

where q is the flow rate, μ the fluid viscosity, L the length, A the cross sectional area of the sample, and ΔP the pressure drop. [5]

Intuitively, it is clear that permeability will depend on porosity; the higher the porosity the higher the permeability. [6] However, permeability also depends upon the connectivity of the pore spaces, in order that a pathway for fluid flow is possible. The connectivity of the pores depends upon many factors including the size and shape of grains, the grain size distribution, and other factors such as the operation of capillary forces that depend upon the wetting properties of the rock. [7]

The permeability of the sandstone is extremely well controlled by the porosity, whereas the carbonate has a more diffuse cloud indicating that porosity has an influence, but there are other major factors controlling the permeability. In the case of carbonates (and some volcanic rocks such as pumice), there can exist high porosities that do not give rise to high permeabilities because the connectivity of the vugs that make up the pore spaces are poorly connected. [8,9]

Poroperm trends for different lithologies can be plotted together, and form a map of poroperm relationships[10], as shown in Fig.1

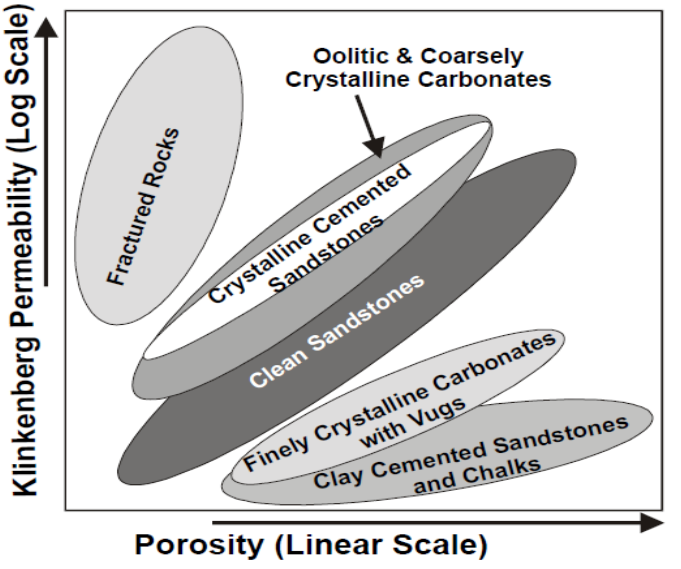

Fig. 1 : Poroperm relationships.

The permeability of rocks varies enormously, from 1 nanodarcy, nD (1□10-9 D) to 1 microdarcy, □D (1□10-6 D) for granites. [11] Shales and clays that form cap-rocks or compartmentalize a reservoir, to several darcies for extremely good reservoir rocks. In general a cut-off of 1 mD is applied to reservoir rocks, below which the rock is not considered as a reservoir rock unless unusual circumstances apply (e.g., it is a fractured reservoir). For reservoir rocks permeabilities can be classified as in Table 1 below. [12]

Table .1: Reservoir permeability classification

Permeability , (md)	Classification
< 10	Fair
10 – 100	High
100 -1000	Very High
> 1000	Exceptional

Many correlations between permeability and porosity have been reported, like Purcell (1949) , Thomeer (1983) ,Swanson (1981), Kamath (1992).

Database and Objectives of This Study

The Aswad field is located in the concession area NC74B, in the extreme southwest of the Sirte Basin. A total of 100 data sets that included measurements of k and Φ were used in the present study. The main objective of the present study was to test correlations between k, Φ

In this study, the relationship between permeability and porosity has been found, but not clear for all permeability readings. The samples were divided into four groups, based on the classification of permeability, and compared to the relationship in the case of being as one group.

Table 2 : experimental reading for porosity & Fair permeability

Sample	Total porosity (%)	Permeability (md)
A1	12	1.4
A2	12.5	1.6
A3	12.1	2.0
A4	15	2.6
A5	13	1.9
A6	14	2.0
A7	14.1	2.0
A8	13	2.5
A9	12.7	4.3
A10	20	6.1
A11	11	0.8
A12	35	7.3
A13	12.6	1.5
A14	30	6.8
A15	32	5.7
A16	50	9.5
A17	41	7.2
A18	44	7.6
A19	36	7.5
A20	14	2.1
A21	19	1.8
A22	24	7.0
A23	38	8.1
A24	39	8.5
A25	10	1.2

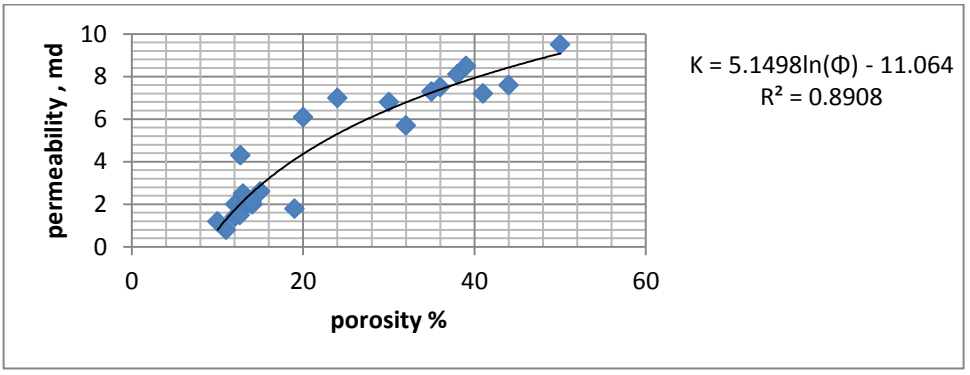

Fig .2 : Correlation between permeability and porosity for data set with K< 10 md

Table 3 : experimental reading for porosity & High permeability

Sample	Total porosity (%)	Permeability (md)
B1	25	23
B2	10	40
B3	29	50
B4	33	22
B5	18	15
B6	12	34
B7	10	25
B8	27	85
B9	38	35
B10	19	78
B11	11	55
B12	37	47
B13	31	67
B14	28	35
B15	24	24
B16	41	15
B17	50	59
B18	9	75
B19	12	53
B20	17	75
B21	24	53
B22	18	68
B23	20	57
B24	22	24
B25	34	12

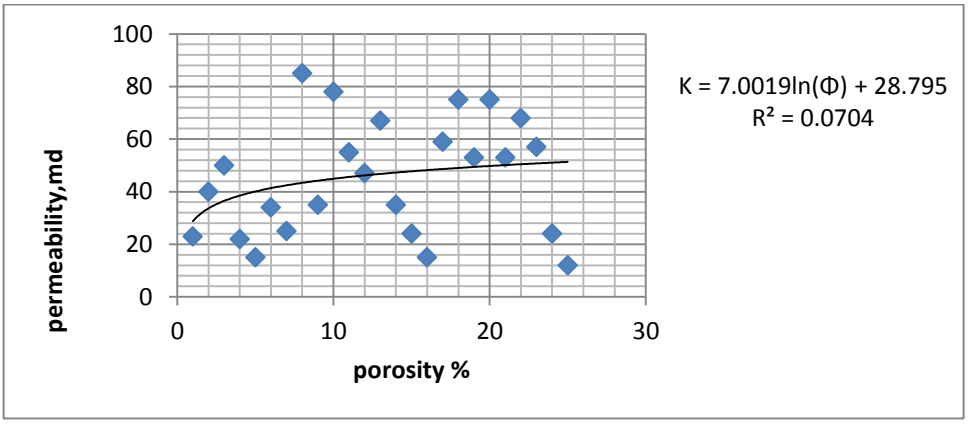

Fig. 3 : Correlation between permeability and porosity for data set with 10<K<100 md

Table 4 : experimental reading for porosity &Very High permeability

Sample	Total porosity (%)	Permeability (md)
C1	29	243
C2	21	587
C3	14	456
C4	18	951
C5	37	753
C6	31	741
C7	25	852
C8	28	369
C9	17	953
C10	10	751
C11	15	684
C12	18	153
C13	39	846
C14	32	624
C15	50	574
C16	42	254
C17	17	652
C18	13	352
C19	15	658
C20	34	785
C21	38	442
C22	36	689
C23	10	623
C24	25	475
C25	28	252

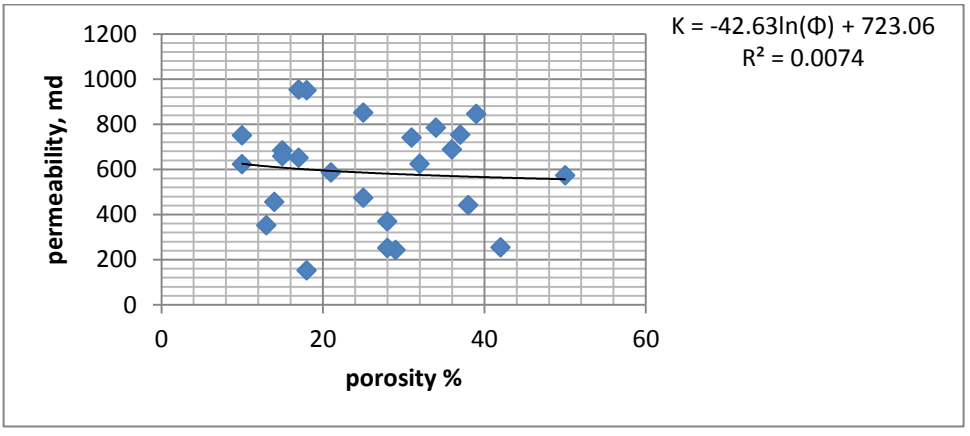

Fig .4 : Correlation between permeability and porosity for data set with 100<K<1000 md

Table 5: experimental reading for porosity &Exceptional permeability

Sample	Total porosity (%)	Permeability (md)
D1	50	3521
D2	25	2564
D3	27	9587
D4	33	7532
D5	34	1478
D6	26	1532
D7	18	9562
D8	37	3578
D9	42	9865
D10	49	7845
D11	37	3254
D12	31	7596
B13	24	4561
D14	26	1547
D15	17	9514
D16	18	1532
D17	10	6587
D18	28	7856
D19	35	4523
D20	29	3254
D21	24	6594
D22	11	4875
D23	22	2525
D24	28	6985
D25	39	7548

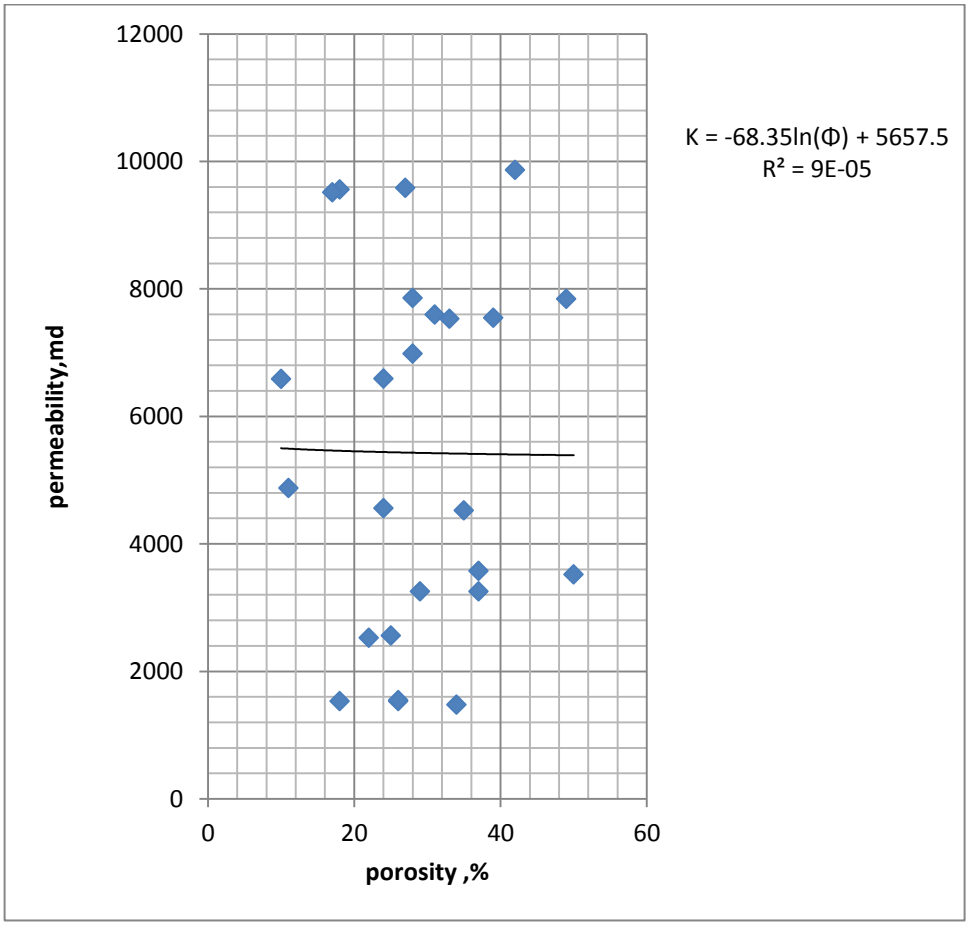

Fig .5 : Correlation between permeability and porosity for data set with K >1000 md

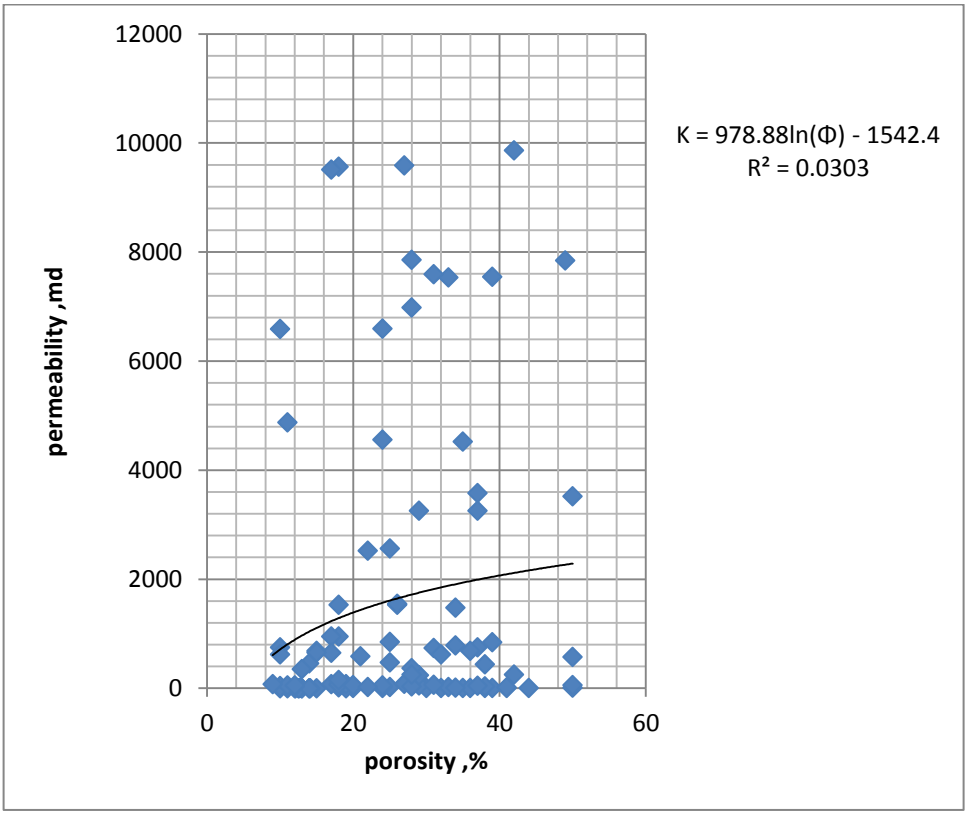

Fig .6 : Correlation between permeability and porosity for all permeability data

RESULTS AND DISCUSSION

Examination of a very large set of permeability, porosity data showed weak correlations exist Especially for some permeability readings.

- The correlation between permeability and porosity when K< 10 md is shown in Fig. 2 (correlation coefficient $R^2 = 0.8908$). $K = 5.1498\ln(\Phi) - 11.064$
- The correlation between permeability and porosity when 10<K<100 md is shown in Fig. 3 (correlation coefficient $R^2 = 0.0704$). $K = 7.0019\ln(\Phi) + 28.795$

- The correlation between permeability and porosity when 100<K<1000 md is shown in Fig. 4 (correlation coefficient R^2= 0.0074). K = -42.63ln(Φ) + 723.06
- The correlation between permeability and porosity when K >1000 md is shown in Fig.5 (correlation coefficient R^2 = 9E-05). K= -68.35ln(Φ) + 5657.5
- The correlation between permeability and porosity for all permeability data is shown in Fig .6 (correlation coefficient R^2 = 0.0303). K = 978.88ln(Φ) - 1542.4

CONCLUSIONS

We can make some generalizations if all other factors are held constant:

- The higher the porosity, the higher the permeability.
- The smaller the grains, the smaller the pores and pore throats, the lower the permeability.
- The smaller the grain size, the larger the exposed surface area to the flowing fluid, which leads to larger friction between the fluid and the rock, and hence lower permeability.

Also permeability:

*· Depends upon porosity.

·* Depends upon the connectivity of the flow paths in the rock.

·* Depends, therefore, in a complex way upon the pore geometry of the rock.

*· Is a directional quantity that can be affected by heterogeneous or directional properties of the pore geometry.

* I expect that by taking more samples, the relationship between permeability and porosity will be clearer.

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Gasoline Blending of Future Libyan Refineries to Satisfy Future Local Demand

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الخلاصة

من المتوقع زيادة إنتاج النفط الخام والغاز الطبيعي في ليبيا في المستقبل القريب بسبب مشروع خليج سرت المستقبلي.حيث أجرت (NOC) دراسات مستفيضة بشأن الاحتياطيات الضخمة المتوقعة من النفط الخام والغاز الطبيعي في الحقل. تتوقع الدراسة إنتاجا كبيرا من النفط الخام والغاز الطبيعي.

تم توقيع عقد لحفر 14 بئر من قبل شركتين عالميتين كبيرتين ، إكسون موبايل وشركة البترول البريطانية. تم إجراء العديد من الدراسات لبناء مصفاة جديدة لمعالجة 500 ألف برميل يوميًا من النفط الخام المختلط المنتج من الصحراء والبحر. ستتألف المصفاة من عمود التقطير الجوي ، ووحدة التفريغ ، والتكسير التحفيزي ، وإعادة التشكيل التحفيزي ، ووحدة الأزمرة ، والألكلة ، والتكسير الهيدروجيني. الهدف الرئيسي من هذه المصفاة هو القضاء على النقص في إنتاج البنزين في ليبيا.

وستكون هذه المصفاة قادرة على إنتاج ما بين 100،000 إلى 170،000 برميل يوميًا من البنزين لتغطية احتياجات الاستهلاك في الأسواق المحلية. حيث تم فيها تعديل مواصفات البنزين باستخدام (MTBE) لتلبية متطلباترقم الأوكتان و البيوتان الطبيعي لضبط (Ried Vapor pressure). تم استخدام نموذج مزج البنزين في هذه الورقة واستخدام طريقة(Rung Kutta) لنمذجة النظام ثم استخدام) (MATLAP softلمحاكاة النظام. سيتم تلبية الاحتياجات الليبية من البنزين لسنوات عديدة قادمة.

Abstract

Production of crude oil and natural gas are expected to be boosted in Libya in near future because of gulf of Sirt future project. National oil company of

Libya (NOC) made extensive studies regarding the huge reserves of crude oil and natural gas expected in the field. The study expects a large production of crude oil and natural gas. A contract has been signed to drill 14 offshore wells by two major world companies, Exxon mobile and British petroleum. this study has been conducted to design a new complex refinery to process 500 thousand barrels per day of mixed crude oil produced from desert and offshore. The refinery will consist of Atmospheric distillation column, vacuum unit, catalytic cracking, catalytic reforming, isomerization unit, alkylation and hydrocracking. The main objective of this refinery is to eliminate the shortages of gasoline production in Libya.

This refinery will be able to produce from 100,000 to 170,000 barrels per day of gasoline to cover the consumption needs in the local markets. Gasoline specifications have to be adjusted using MTBE to satisfy the octane number requirement and n-butane to adjust the Reid vapor pressure. Gasoline blending model have been utilized in this paper. Rung Kutta method have been used to model the system and MATLAB soft were is utilized to simulate the system. Libyan requirement of gasoline will be met for many years to come.

Key words : Gasoline blending , Libyan refineries, MTBE.

Introduction

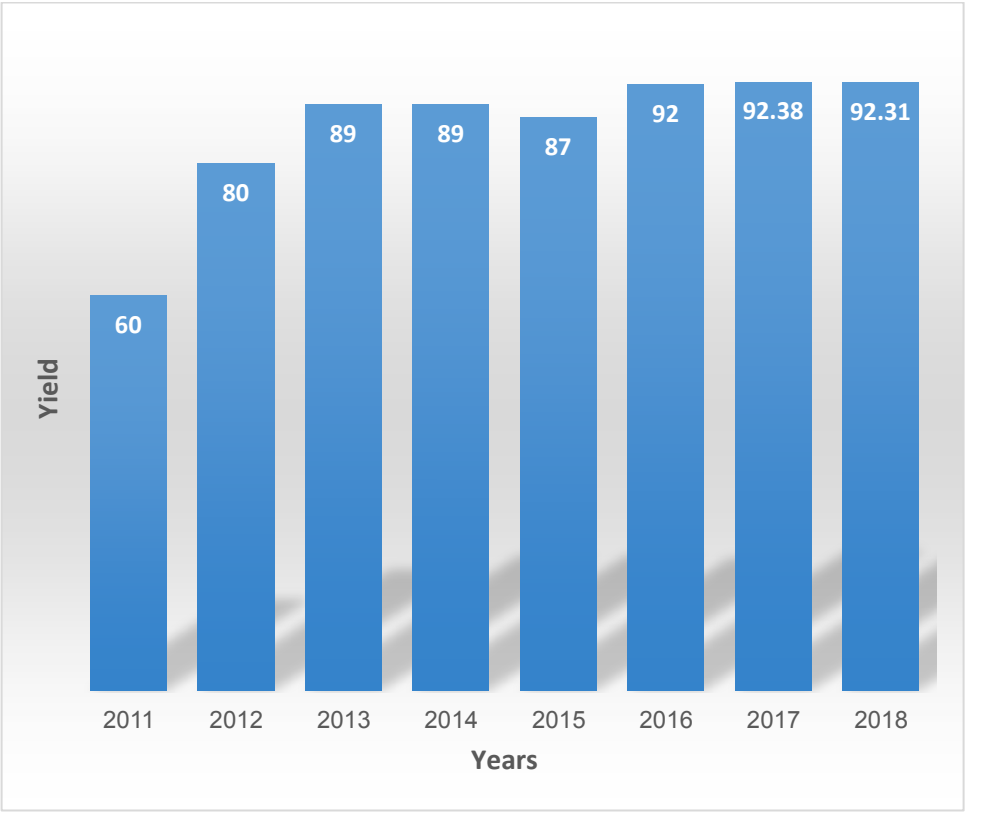
Gasoline is a complex of hundreds of different hydrocarbons. Most are saturated and contains 4 to 12 carbon atoms per molecules. Gasoline can be produced in various process in a modern oil refinery. Due to the different sources of gasoline streams, they contain both superior and inferior properties.

The gulf of Sirt gas and crude oil future project is expected to be the largest project in the world in near future. National Oil Corporation (NOC) in Libya signed a contract with EXXON mobile and British petroleum oil companies to assess the project where 14 Wells to be drilled in the gulf of Sirt at cost 7 billion dollars in near future due to the huge depth of sea water in this location. An estimated production rate of 40 billion cubic meters of natural gas with several million barrels per day of heavy crude oil is expected. A huge pipe line will be built to transport 80% of the gas to Italy where the other 20% will be processed in gulf of Sirt to satisfy local demand in Libya in the near future.

This paper will concentrate on building a new crude oil refinery in gulf of Sirt with a capacity of 500 thousand bbl per day to satisfy the Libyan consumption of gasoline in future. A huge shortage of gasoline in Libya reaching 70% of local demand will the eliminated.

Besides, different marketing locations served by a refinery may have different requirement and regulatory specifications that may also vary seasonally. Therefore, refiners need to select optimal combinations of various intermediate gasoline intermediates in a particular blending ratio to produce on-specification products[1].In general, gasoline are blended from several petroleum refinery process streams that are produced by the following methods: direct distillation of crude oil, catalytic and thermal cracking, hydrocracking, catalytic reforming, alkylation and polymerization[2]. For instance, the production of gasoline involves mixing a variety of ingredient, such as: alkylate reformate, fluidized catalytic cracking unit(FCC), gasoline and an oxygenated additive named Methyl Tert-Butyl Ether(MTBE) to satisfy the octane number requirement and i-butane to adjusted Ried vapor pressure.The objective of gasoline blending is to find the optimal recipe to achieve a best overall profit while satisfying the environmental regulations and market demand. The blending process of gasoline using the linear software MATLab by using Runge-Kutta method. The overall purpose of this research is to enhance the properties and the gasoline production by adding new units to the major units in Libyan refineries. To accomplish this, the project will be divided into several individual objectives:

1. Collecting data from Azawia and RasLanuf refineries.
2. Add new units to produce gasoline.
3. Material balancing work for major units that used to produce gasoline.
4. Gasoline blending process will be simulated using MATLAB software.
5. Gasoline blending models available in literature will be used to calculate the major physical properties (RVP and ON).
6. Enhancement RVP and OC by using MATLAB program.



Fig(1)Consumption of Gasoline in Libya

Fig (1) shows the consumption of gasoline in the previous year's according to the U.S. Energy Information Administration[2].

The main objective of this paper is to produce enough gasoline in Libya to balance the deficiency of supply demand of gasoline in future. Fig (1) illustrates the consumption of gasoline in the last eight years.

Methodology

Blending gasoline process

In most cases, refining procedures don't result in fully finished goods that can be sold directly; instead, they generate semi-finished goods that must be combined to fulfill the requirements of the desired products. The basic goal of product blending is to determine the most effective approach to combine

various intermediate products that are accessible from the refinery with some additives in order to modify the product specifications. For instance, the production of gasoline involves mixing a variety of ingredients, such as alkylate, reformate, FCC gasoline, and an oxygenated additive such (MTBE), in order to raise the octane number[3]

Oxygenated fuels, such as alcohols and ethers, may be able to meet the world's rising energy needs in the future while also being environmentally friendly. Since they may be produced locally and from a variety of renewable sources, oxygenated fuels have a promising future. There are two crucial requirements for every gasoline blend, however they are not the only ones. Both the RVP, and the ON of the gasoline must be at the right levels. While a certain grade's octane remains the same all year long.

In this stage, gasoline cuts obtained from the distillation unit were blended in gasoline pool using MATLAB software[4]

Gasoline blending with MTBE

This step will be divided into three sections:

1. Quantities of materials used for the blending process.

2. Time of blending.

3. Enhancement physical properties of gasoline produced.

Quantities of additives materials

For the process of blending gasoline, the quantities of materials used are required, as well as the time of mixing the mixture. In order to accomplish this, several steps were performed. The values of octane numbers and Reid vapor pressure of different technologies unit streams are listed in TABLE 2. The results of octane number and Reid vapor pressure are needed to be adjusted to satisfy the Libyan standard specifications. Methyl tertiary butyl ethers and isobutene are added to Gasoline pool to satisfy the requirement.

TABLE 1: Octane numbers and Reid Vapor pressure of Refining units

Component	RVP(psia)	RON	MON	$ON = \frac{RON + MON}{2}$
FCC	1.4	92.1	77.1	84.6
Catalytic reformate	2.8	94	84.4	89.2
Delayed Coker	3.6	67.1	60.2	63.7
Isomerization	13.5	83	81.1	82.05
Alkylation	4.5	97.3	95.9	96.6
Hydrocracking	12.9	82.8	82.4	82.6
Total	$\sum \frac{39}{6} = 6.5$			$\sum \frac{500.3}{6} = 83.4$
i-C4	71	93	92	92.5
MTBE	9	101	118	110

In this paper, the process of blending gasoline, the quantities of material used are required, as well as the time of mixing the mixture; where important properties of additives are identified and then calculated the amount of MTBE and i-C4 that are calculated by using the following mathematical equation:

$$(MTBE * OC_{MTBE}) + (FCC * OC_{FCC}) + (Cataytic\ reformate * OC_{cat \cdot ref}.) + (Delayed\ Coker * OC_{Dela \cdot Cok}) + (Isomerization * OC_{Iso}.) + (Alkylation * OC_{Alky}.) + (Catalytic\ Hydrocracker * OC_{Cata \cdot Hydro}.) = (Gasoline\ Pool * OC_{Gas \cdot Pool}) \quad (1)$$

$$(i-C4*RVP_{ic4})+(FCC*RVP_{FCC})+(Cataytic\ reformate*RVP_{Cat\cdot ref}.)+(Delayed\ Coker*RVP_{Del_{Cok}}.)+(Isomerization*RVP_{Iso}.)+(Alkylation*RVP_{Alky}.)+(Catalytic\ Hydrocracker*RVP_{Cata\cdot Hydro}.)=(Gasoline\ Pool*RVP_{Gas\cdot Pool}) \quad (2)$$

Where:

MTBE: The amount of MTBE (BPD).

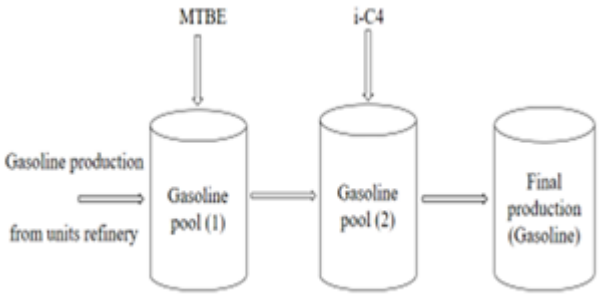
OC : The octane number of all material.

i-C4 : The amount of iso-butane (BPD).

RVP : The Reid vapor pressure (psia).

Model development

1) Consider an empty cylindrical tank represent final product (gasoline tank) in which gasoline from product units is to be prepared (blended) by adding MTBE in (gasoline pool (1) tank) and i-C4 in (gasoline pool (2) tank) as shown in Figure (2).
2) The three components are gasoline from product units have (low octane) and MTBE have (high octane), i-C4 have (high RVP) and gasoline pool (low RVP).
3) The percentage volume of the cylindrical tank is 100% by volume.
4) The sum of the percentage volume of the three components flowing in is equal to the volume flowing out.
5) The gasoline products from units in refinery and the MTBE enters to tank of gasoline pool (1) with RON1, RVP1.
6) The gasoline pool (1) and i-C4 enters to the tank of gasoline pool (2) with RON2, RVP2.
7) The tank is well mixed after transferring the components into the cylindrical tank.
8) Final product (Gasoline) leaves tank after mixing process, where the final blend is homogeneous with specific RON, RVP.



Fig(2) Model Development

Model Equations:

The rate of change of the dependent variable is equal to the **rate of flow from tank1 plus the rate of flow from tank2 minus** the rate of flow from tank3.

$$\frac{dA(t)}{dt} = (r1A1 + r2A2) - r3A(t) \qquad ; A(t) = ON$$

$$\frac{dB(t)}{dt} = (r1B1 + r2B2) - r3B(t) \qquad ; B(t) = RVP$$

r_1 and r_2 are determined using simultaneous equation from material balance

$$A1 + A2 = 94$$

Where : A1 and A2 are the MTBE and gasoline from units of refinery for the blend respectively.

Fourth Order Rung-Kutta numerical Solution:

To find the initial value and solve the differential equations we can use the Rung-Kutta method as follows:

$$\frac{dy(t)}{dt} = f(t,y) \quad ; \quad a \le t \le b \; ; y(t=a) = ya$$

$$k1 = hf(ti, yi)$$

$$k2 = hf(ti + \frac{h}{2}, yi + \frac{k1}{2})$$

$$k3 = hf\left(ti + \frac{hyi}{2}, \frac{k2}{2}\right)$$

$$k4 = hf(ti + h, yi + k3)$$

$$y(i+1) = yi + \frac{1}{6}(k1 + 2k2 + 2k3 + k4)$$

Where: k_1,k_2,k_3 and k_4 are the slopes used to calculate y(i+1)

Simulation of blending gasoline

With the development of technology, the gasoline blending process has evolved to become more efficient and in the least amount of time so that the process can be carried out to the fullest extent. Francis[4,5] proposed three high-quality first-order differential equations in addition to a computer program (MATLAB) where Runge-Equations were used Kutta class IV for blending two gasoline components, model predictions RON (Research Octane Number), RVP (Reid Vapor Pressure) and density of the gasoline mixture were made. The gasoline blending was executed by employing the linear programming solver application in Microsoft excel using four blending components namely the Fluid catalytic cracking gasoline (FCCG), Straight run naphtha (SRN), Straight run gasoline (SRG), Butane, and varying Oxygenates.

In this paper, the MATLAB program will be used for the final blending process of gasoline with oxygenates and iso-butane to modify OC and RVP.

MATLAB programs

This program's goal is to calculate the ON and RVP of the gasoline mixture. The octane number and RVP will remain the same because the gasoline mixing process is for MTBE and iC4. A1 is the gasoline pool's Ron, A2 is the MTBE's Ron, and B1 is the gasoline pool's RVP (RVP OF THE i-C4) as inputs in order to compute R1 and R2 thus the fractions of the components to be blended together. The following diagram shows the process of blending gasoline with improved additives.

I. Gasoline pool (1)

Since the ON values of the units producing gasoline as well as the materials used for mixing are constant see table 2, the output values will be equal for the two ratios used.

Gasoline produced from production operations (refinery units) enters the gasoline pool to be blended with the oxygenating substance MTBE so that the octane number is adjusted to suit the Libyan specification.

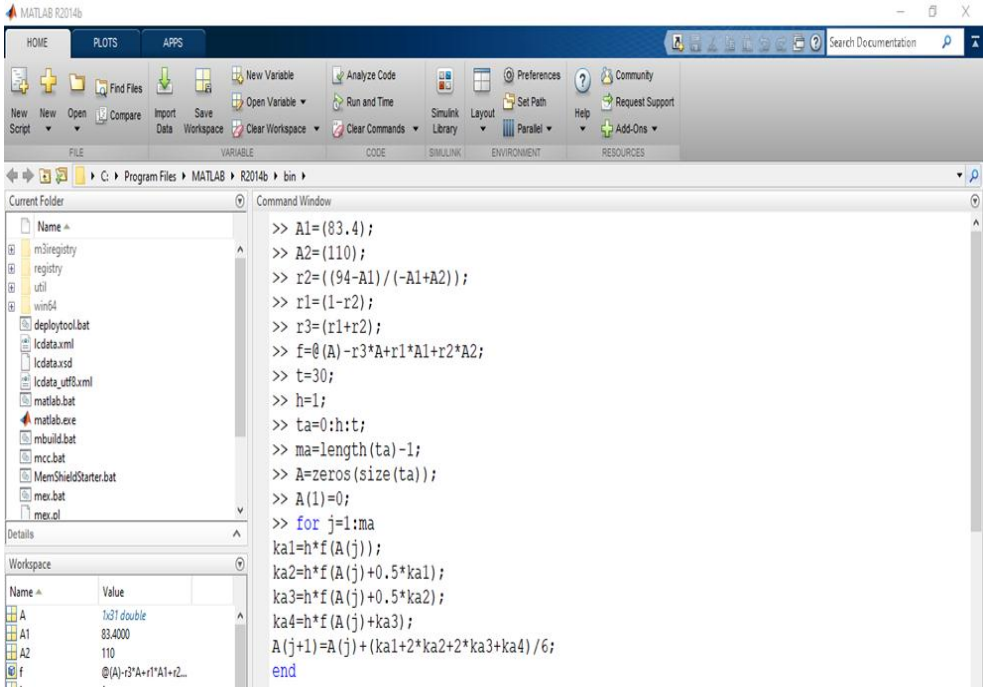


Fig.3 blending ON of gasoline pool with ON of MTBE

Results of blending observed that the process to modify the octane number needs 15 hours for homogenous blending,

After modify ON, we have to modify the value of RVP that changed with time of mixing, so the RVP will be calculated in gasoline pool (1).

II. Gasoline pool (2)

Since the RVP values of the units producing gasoline as well as the materials used for mixing are constant see table 5, the output values will be equal for the two ratios used >> B1=7.5

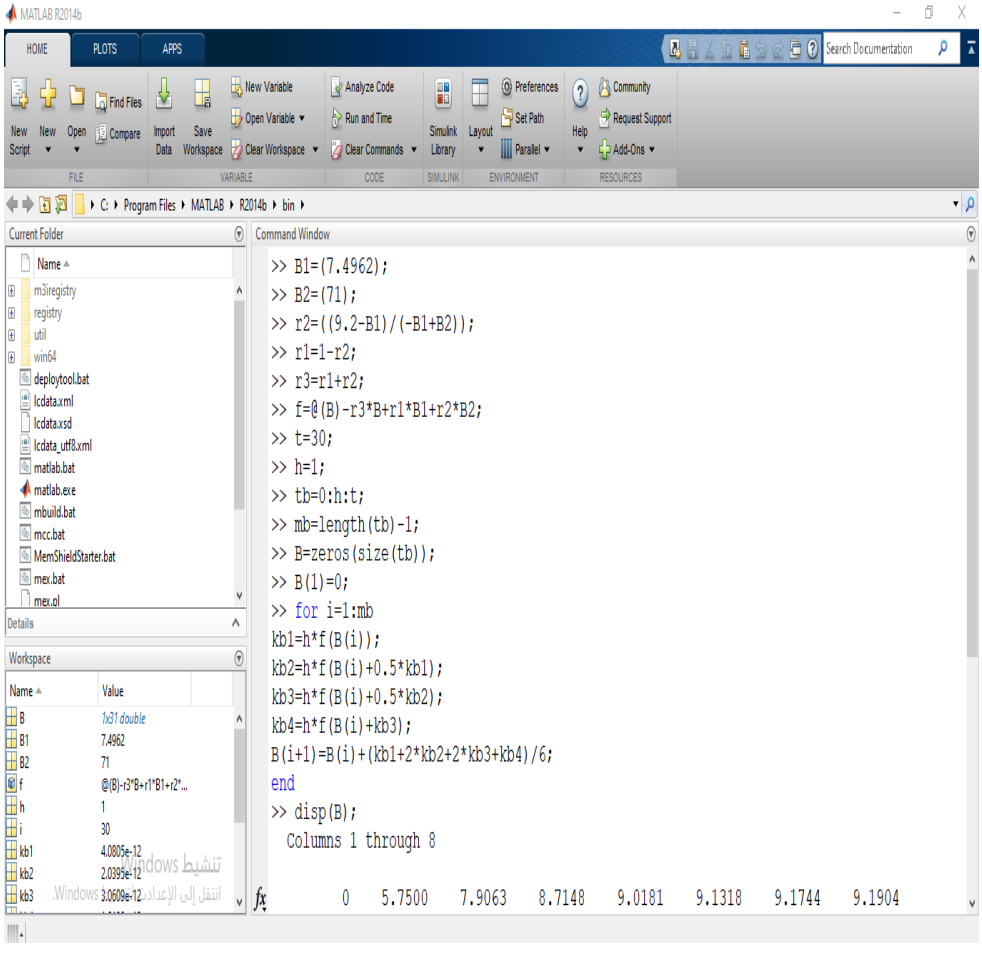


Fig. 4 blending RVP of gasoline pool with RVP of MTBE

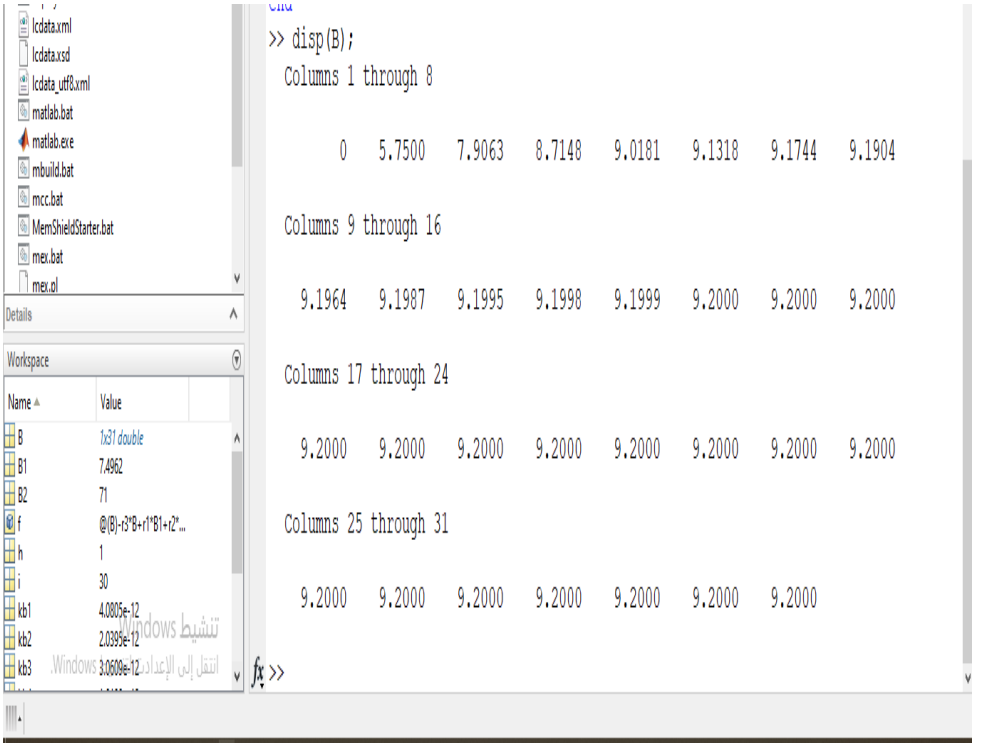


Fig. 5 Result of blending RVP

From fig.5 the RVP needs 13 hours to modify it.

Discussion of simulation results

The total amount that suggested of 500,000 barrels per day of new crude oil entering the atmospheric distillation unit of two different types of Libyan crude oil has been proposed to increase the amount of gasoline production, the results were as shown in Table 2. Table 2 summarizes the results of production of gasoline obtained from two mixtures of crude oil of different quality by using several different units. Where it was found that the second mixture produces 177,675 BPD, which is a profitable production compared to the first mixture, which produced 86,270 BPD, and according to the total consumption of gasoline in Libya, it is possible to satisfy Libyan demand of Gasoline in future.

Table 2 : Results of gasoline by BPD from different units

Description	First mixture	Second mixture
FCC	16,606	33,411
Catalytic reformate	22,710	44,914
Delayed cooker	4,097	2,892
Isomerization	18,398	22,391
Alkylation	8,846	17,885
Catalytic hydrocracking	6,427	4,619
Gasoline pool	∑77,084	∑126,112
Enhanced gasoline	86,270	177,675

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Adsorption separation Technique

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الملخص

على مدى العقود القليلة الماضية، كانت تقنيات الامتزاز إحدى الطرق المستخدمة بنجاح في فصل الخلائط الأزيوتروبية. في العمل الحالي، تمت دراسة فروع شجرة الأوكالبتوس (Eu-GAC) وممتصات السيليكا (الرمل) باستخدام وعاء الامتزاز الدفعي لقياس قدرتها على الامتزاز. تمت دراسة تأثير وقت التلامس وجرعة الامتزاز في تعزيز عملية الامتزاز. أظهرت النتائج أن عامل Eu-GAC كممتز يبدو أكثر كفاءة مقارنة بعامل الرمل بنسبة 98٪ تقريبًا.

Abstract

For the past few decades, adsorption techniques are one of the methods used successfully in separating azeotropic mixtures. In the present work, Eucalyptus tree branches (Eu-GAC) and Silica adsorbent (Sand) have been studied by using a Batch Adsorption vessel to measure their capability for adsorption. The effect of contact time and adsorption dose in enhancing the adsorption process has been investigated. The results showed that the Eu-GAC agent as adsorbent appears more efficient compared to the sand agent with almost 98%.

Keywords*:* Azeotropic mixture; Eucalyptus tree branches (Eu-GAC); Silica adsorbent (Sand); adsorbents doses.

1. Introduction.

The term “azeotropy” denotes a mixture of two or more components where the equilibrium vapor and liquid compositions are equal at a given pressure and temperature. More specifically, the vapor has the same composition as the liquid and the mixture boils at a temperature other than that of the pure components boiling points [1]. Azeotropic mixture is a special mixture with a boiling point higher or lower than its components. Therefore,

the common distillation methods widely used have not led to separate the azeotropic mixture into pure components. Several methods such as decompression distillation and additive distillation have been applied to separate azeotropic, however, these processes have accompanied with wasting excessive energy. Although chromatography has an important role in the mixtures separation including azeotropic mixtures, it is just used for the analysis due to the disability to separate large amount of the mixture [2]. Some adsorbents, such as synthetic resins, dehydrating agents and more, are very expensive to achieve economically the separation process of azeotropic mixtures [3].

Benzene and cyclohexane classify as important materials since they constitute the raw materials of various petrochemical products. Because the boiling points of these compounds are very close, azeotropic and extractive distillation are frequently used for their separation by adding a third component. During the last decade, a number of polymer membranes have been developed for the separation of a benzene/ cyclohexane mixture. However, in the separation, including aromatic compounds with high adsorptivities, the polymer membranes become swollen due to the accumulation of highly adsorptive compounds in the membrane resulting reducing the separation factors. Thus, inorganic membranes such as zeolite are expected to be effective membranes to separate benzene and cyclohexane. Separation of benzene and cyclohexane by adsorption technique may be identified as an azeotropic mixture [4].

Separation of benzene and cyclohexane is recognized to be the most important and difficult processes in the petrochemical industry. Cyclohexane is produced by catalytic hydrogenation of benzene. The unreacted benzene occurred in the reactor's effluent stream and must be removed for pure cyclohexane retrieving. Separation of benzene and cyclohexane is difficult by a conventional distillation process because these components have close boiling mixtures at the entire range of their compositions. Presently, azeotropic distillation and extractive distillation are used for this separation. These two processes, however, suffer from complexity and high energy consumption. For all these reasons, the industry has always been eager to look for an alternative method to the conventional separation processes [5].

The investigation of the adsorption isotherm aimed to measure the adsorption capacity of the adsorbents (Eu-GAC and Sand) and to determine the equilibrium distribution of the solute concerned (e.g. benzene in the

azeotropic mixture benzene-cyclohexane). In this study, the investigation of the efficiency of Eu-GAC and Sand to separate the azeotropic mixture benzene-cyclohexane was carried out.

2. Materials and methods.

2.1Materials.

In this study, we have used activated carbon obtained from Eucalyptus tree branches (Eu-GAC) and Silica adsorbent (Sand) from seaside of El-Khoms. The carbon was produced by thermal pyrolysis of Eucalyptus tree branches in the absence of oxygen. The activated carbon was used without any further treatment except drying in an oven at 100˚C before usage. The sand was washed with ethanol and then dried at 100˚C.

2.2. Method.

In this research, the azeotropic mixtures were prepared from commercial fine reagents according to the components and the ratios. Three types of azeotropic mixtures of benzene and cyclohexane were prepared containing 4%, 6% and 8% benzene in cyclohexane.

All readings were made on a UV-Visible spectrophotometer (model 8700 series Unicam UV/Vis) (Figure 1). The absorbance's of the solutions were measured at the wavelength (255 nm) [6], as benzene absorbs at this wavelength while, cyclohexane has no absorbance above 200 nm. The absorbance readings obeyed Beer's law in this range.

Ai = S * Ci Where: Ai: absorbance (%), S: constant, slope of curve and Ci: concentration, mg / L.

Figure1: UV-Visible (Spectrophotometer).

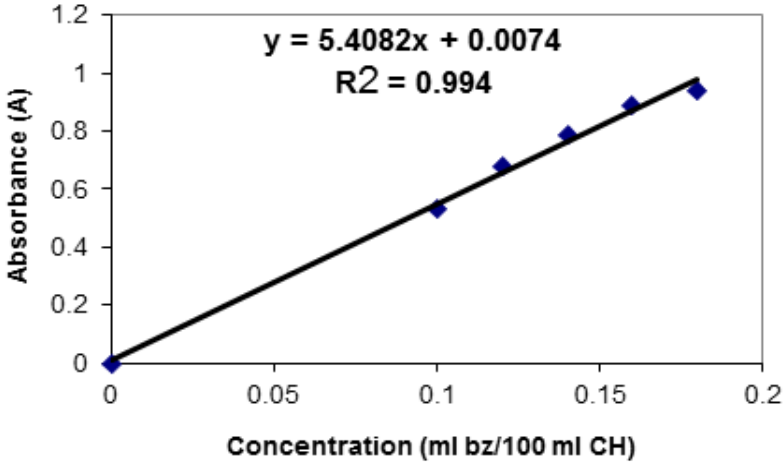

Figure 2: Calibration Curve for the Azeotropic Mixture, (Benzene-Cyclohexane).

2.3. Equilibrium Adsorption studies,

An azeotropic mixture prepared by mixing 0.1-0.18 ml (874 - 1572 mg/L) of benzene with cyclohexane to obtain 100ml solutions containing 4 %, 6 % and 8 % benzene solutions. The experiments were carried out using Eucalyptus (Eu-GAC) and Sand as adsorbents, and were performed at the following conditions:

1. The equilibrium isotherm measurements were carried out for different solution/solid ratios and at constant temperature of 25 ± 2˚C.
2. The equilibrium shaking time (contact time) was varied from one to 15 hours at an stirring speed of 200 rpm.
3. The experiments were conducted in 125 ml Erlenmeyer flasks on a magnetic stirring apparatus as showed in (Figure 3).
4. The ratio of solution/adsorbent was varied from 1 to 3 gm, and the samples were collected at the intervals time.
5. Samples were analyzed by UV/VIS spectrophotometer by measuring absorbance of the samples at λmax (255 nm) for benzene - cyclohexane.

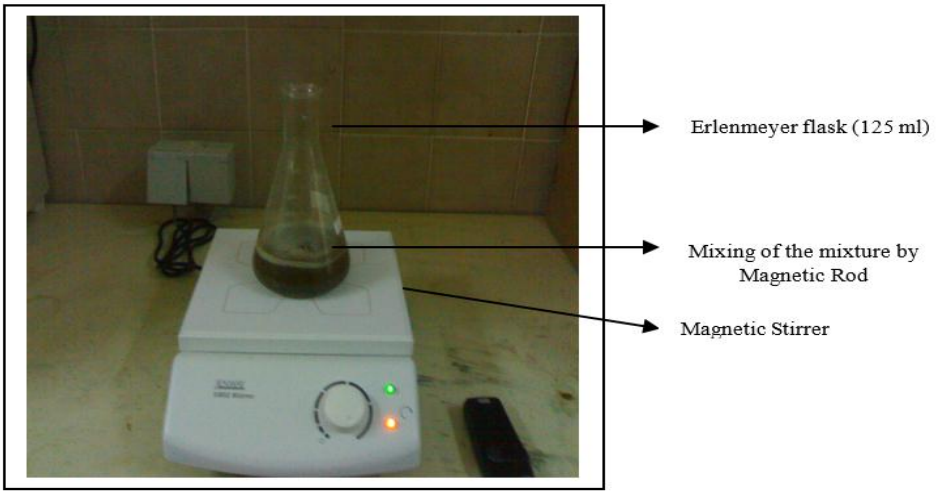

Figure 3: Stirred Batch Adsorption Vessel for Kinetic Studies

3. Results and discussion.

The investigation of the adsorption isotherm aimed to measure the adsorption capacity of the adsorbents (Eu-GAC and Sand) and to determine the equilibrium distribution of the solute concerned (e.g. benzene in the azeotropic mixture benzene-cyclohexane).

3.1 Effect of Contact Time.

Results in Figures 4 and 5 show that the adsorbed benzene increases with an increase the contact time. Other parameters such as dose of adsorbent and pH of solution were kept at optimum situation as well as the temperature was kept at 25˚C. The adsorption efficiency increases when contact time increases from one to 3 hours. Optimum contact time for adsorbed Benzene-Cyclohexane in both adsorbent agents (EU-GAC and Sand) was found to be 4 hours. It is clear that the EU-GAC agent was found to be more efficient than the sand. This result agreed with what was found by Othman [7].

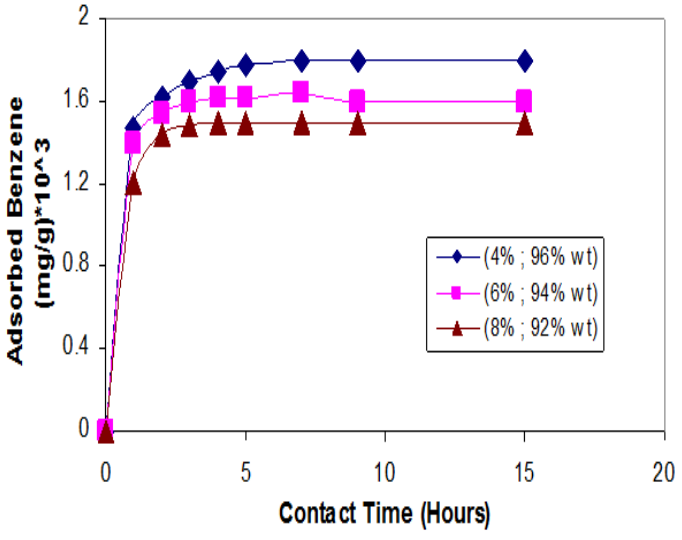

Figure 4: Effect of Contact Time on the Adsorption of Azeotropic Mixture, (Benzene-Cyclohexane) of different initial concentrations, by EU-GAC (1g; Mesh No 100) pH=3; Stirring Speed 200rpm; T= 25˚C, atm.

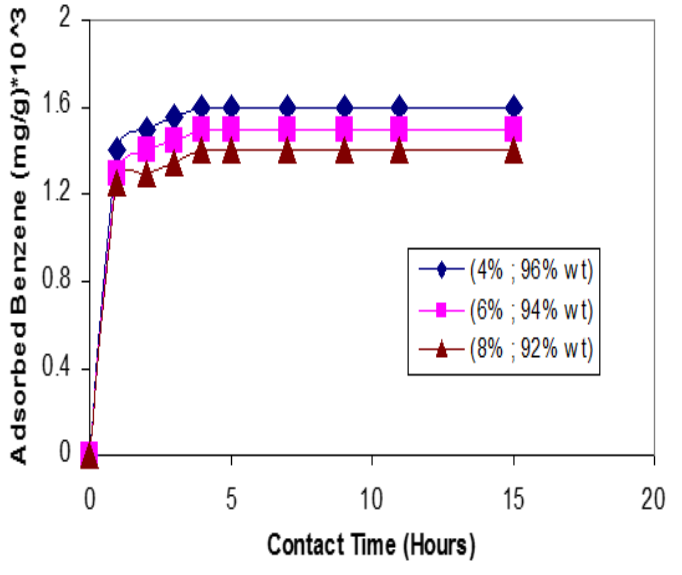

Figure 5: Effect of Contact Time on the Adsorption of Azeotropic Mixture, (Benzene-Cyclohexane) of different initial concentrations, by Sand (1g; Mesh No 100), pH=3; Stirring Speed 200rpm; T= 25˚C,1atm.

3.2 Effect of Adsorbent Dose

The adsorption of benzene on Eu-GAC and Sand adsorbents was examined by using various amount of adsorbents doses from 1g to 3g/100 ml. Figures (6, 7 , 8 and 9) present the adsorption efficiency of benzene on two adsorbents. From these figures, we can conclude that the adsorption efficiency of the adsorbents generally improved by increasing adsorbents dose. The percentage removal of azeotropic mixture from the solution increased from 80-95% to 87-97% as the adsorbent dosage increased from 1g to 3 g for Eu-GAC adsorbent. Whereas the percentage removal of azeotropic mixture from the solution increased from 70-90% to 75-93% as the adsorbent dosage increased from 1g to 3g for sand. This result is expected because of the increased adsorbent surface area and availability of more adsorption sites caused by increasing adsorbent dosage [8].

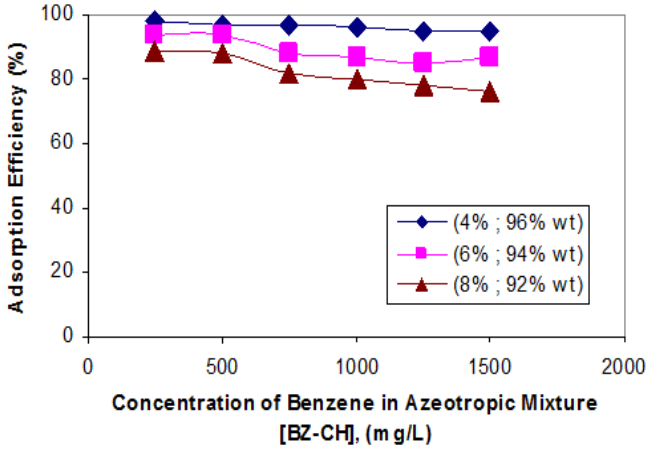

Figure 6: Adsorption percent of the Azeotropic Mixture, (Benzene-Cyclohexane) onto EU-GAC (1g ; Mesh No 100) with different compositions; T= 25 oC,1atm.

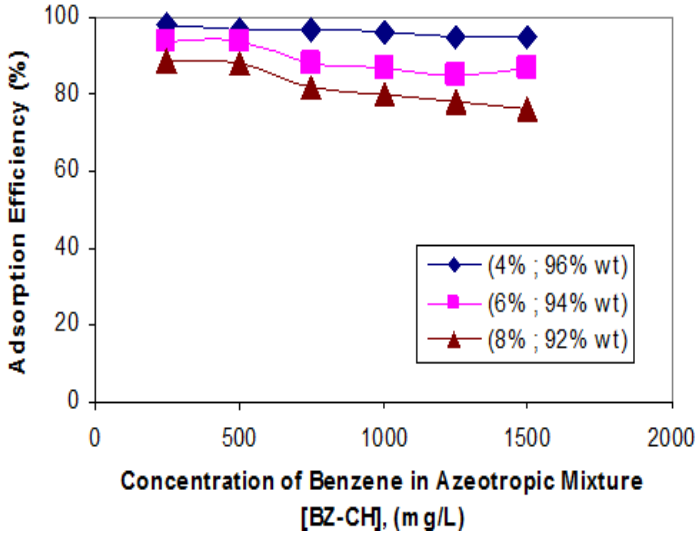

Figure 7: Adsorption percent of the Azeotropic Mixture, (Benzene-Cyclohexane) onto EU-GAC (3g ; Mesh No 100) with different compositions; T= 25 oC,1atm.

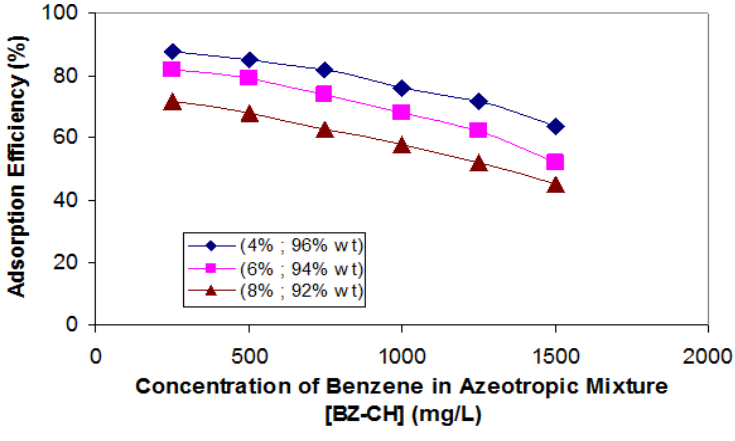

Figure 8: Adsorption percent of the Azeotropic Mixture, (Benzene-Cyclohexane) onto Sand (1g ; Mesh No 100) with different compositions; T= 25 oC,1atm.

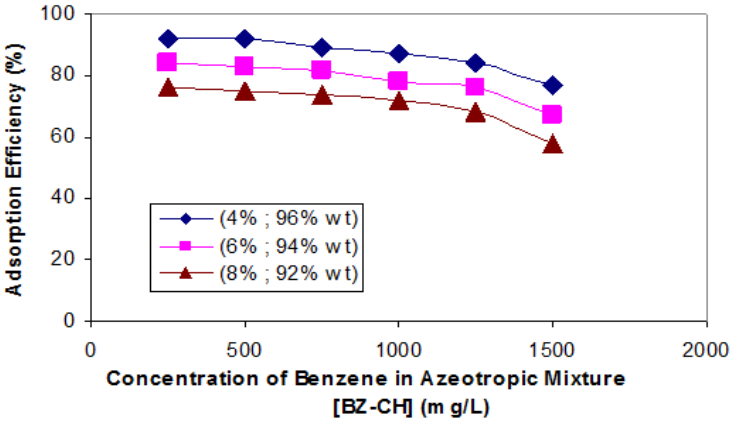

Figure 9: Adsorption percent of the Azeotropic Mixture, (Benzene-Cyclohexane) onto Sand (3g ; Mesh No 100) with different compositions; T= 25 oC,1atm.

4.Conclusion.

In conclusion, we have studied the adsorption isotherms and adsorption efficiency of the two adsorbents Eu-GAC and Sand to separate the azeotropic mixture benzene-cyclohexane in batch column techniques. The adsorption efficiency increased with an increase in contact time, the optimum contact time for both agents was three hrs. The dependence of the adsorption efficiency of benzene on the two adsorbents was studied and it was found that the efficiency is dependent on the dose of the adsorbent and increases with the increase in dose. The behavior of Eu-GAC as an adsorbent appears to us better than sand, it has shown high separation efficiency in the range between 80-97% at different doses.

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Effects of ISO 9001 as a Mediator between TQM, Organizational Performance, and the Baldrige Excellence Framework in the Libyan firms

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الملخص

تطبق معظم المنظمات التنافسية إدارة الجودة الشاملة (TQM) ، والتي تُعرف على نطاق واسع بأنها استراتيجية رئيسية تُستخدم من قِبَل المنظمات التنافسية لتحسين أدائها بشكل مستمر. ومع ذلك، تشير الدراسات إلى أن اعتماد TQM وأنظمة إدارة الجودة (QMS) كان بطيئًا في ليبيا , إذ يظل عدد الشركات المعتمدة بموجب معيار ISO 9001 في ليبيا مقارنةً بالدول العربية الأخرى صغيرًا نسبيًا، مما يشير إلى نقص الحماس والوعي بشأن أهمية TQM في تلبية احتياجات المجتمع الليبي. لمعالجة هذه الفجوة ، تهدف هذه الدراسة إلى تطوير نموذج مفاهيمي شامل لتنفيذ إدارة الجودة الشاملة TQM في القطاع الصناعي في ليبيا ، مع التركيز على العلاقة بين إدارة الجودة الشاملة TQMوشهادة ISO 9001 والأداء التنظيمي.

للتحقيق في النموذج المقترح ، يتم استخدام تحليل المسار باستخدام نمذجة المعادلات الهيكلية (SEM) لإنشاء تطبيقات إدارة الجودة الشاملة (TQM) والتحقق من صحتها والتأثير على الثقافة التنظيمية والأداء. يوفر النموذج المقترح فهماً أفضل للعلاقة بين إدارة الجودة الشاملة TQM والأداء التنظيمي في ليبيا. ينصب تركيز هذه الورقة بشكل أساسي على الحالة الفعلية لتنفيذ إدارة الجودة الشاملة (TQM) ، حيث تطبق جميع الشركات برامج رسمية لإدارة الجودة الشاملة TQM وتلك التي تطبق بشكل أساسي ممارسات إدارة الجودة الشاملة TQM . تم اختبار الفرضيات لتحديد العلاقة بين إدارة الجودة الشاملة TQM و OP لتحديد الوسطيات التي تؤثر على ISO 9001. ووجد أن ISO 9001 لها علاقة إيجابية بين إدارة الجودة الشاملة TQM و OP كوسيط للمصنعين الليبيين.

إن الأفكار المكتسبة من هذه الدراسة لها آثار على المنظمات التي تهدف إلى تحسين أدائها من خلال ممارسات إدارة الجودة الشاملة ويمكنها توجيه مبادرات السياسات التي تهدف إلى تعزيز اعتماد أوسع لشهادة إدارة الجودة الشاملة TQM وشهادة ISO 9001 في القطاع الصناعي الليبي.

الكلمات المفتاحية : إدارة الجودة الشاملة ، شهادة الأيزو 9001 ، الأداء التنظيمي ، نمذجة المعادلات الهيكلية (SEM).

Abstract

Most competitive organizations apply Total Quality Management (TQM) which is widely recognized as a key strategy employed by competitive organizations to continuously improve their performance. However, studies indicate that the adoption of TQM and Quality Management Systems (QMS) in Libya has been sluggish. The number of ISO 9001-certified companies in Libya, compared to other Arab countries, remains relatively small, suggesting a lack of enthusiasm and awareness regarding the importance of TQM in addressing the needs of Libyan society. To address this gap, this study aims to develop a comprehensive conceptual model for implementing TQM in the industrial sector of Libya, focusing on the relationship between TQM, ISO 9001 certification, and organizational performance.

To investigate the proposed model, Path analysis using Structural Equation Modelling (SEM) is used to create and validate TQM applications and influence organizational culture and performance. The proposed model provides a better understanding of the association between TQM and organizational performance in Libya. The concentration of this paper is mainly on the actual state of TQM implementation, with all companies applying formal programs of TQM and those basically implementing TQM practices. Hypotheses were tested to determine the association between TQM and OP to determine mediations affecting ISO 9001.ISO 9001 was found to have a positive relationship between TQM and OP as an intermediary for Libyan manufacturers. The insights gained from this study have implications for organizations aiming to improve their performance through TQM practices and can inform policy initiatives aimed at promoting broader adoption of TQM and ISO 9001 certification in Libya's industrial sector.

Keywords: Total Quality Management, ISO 9001 Certification, Organization Performance, Structural Equation Modelling (SEM).

1. Introduction

Today's manufacturing firms must be competitive in a variety of previously uncompetitive areas, such as products and innovation. The combination of environmental, technical, cultural, economic, and socio-political challenges requires us to respond quickly and effectively in many different areas simultaneously. Several high-quality and TQM initiatives are available for manufacturers to prepare for the current situation and future challenges [1]. Manufacturing is one of the many services in the industrial sector, characterized by excellent customer contact with individually customized service solutions where performance is the focus of research. Key determinants of service performance quality, service capabilities, customer complaints, and situational factors were investigated. Total Quality Management is the future goal of the manufacturing industry and is a technique for continuous improvement aimed at performance. TQM is an approach that has been developed in the manufacturing industry in recent years and can respond directly to the globalization and competitiveness of the manufacturing market [2].

The vast majority of successful manufacturers have adopted TQM to make their tremendous contributions. Therefore, the significance of TQM as an effective pillar for attaining manufacturing brilliance cannot be ignored. The concept of manufacturing excellence is the way to become the best manufacturer. This is the ultimate goal for best-in-class manufacturing capability or performance. Depending on the situation, the mediating effect of corporate entrepreneurship between environmental culture and performance has an indirect negative or positive impact on financial performance that the organization's response level performs and a positive or negative influence on market culture. The indirect effect of being sold through a new business self-renewal. This means that the entrepreneurial nature of companies is more likely to be an intermediary [3].

2. Background of the Study

Total Quality Management is a leadership philosophy and strategy based on continuous improvement of all processes, people empowerment, and continuous learning, with the aim of bringing about organizational change while delivering superior products and services. Many organizations around the world use TQM to improve their competitiveness and financial results [4].

TQM is strongly encouraged to have a good operational policy, but pressure motivates organizational management to evaluate business strategies and practices and to be creative and innovative to improve performance.
In this context, the top management needs to integrate the 'quality vision' into the goals and objectives of the organization. The effectiveness of the organization is consistent with the theory of structural-technical interventions that emphasize productivity, factors of performance, and relationships between workers. Structural technical intervention strategy also focuses on the level of involvement in the organization's development and change process. One of the main interventions identified is the socio-technical system that focuses on the circuits of quality control and total quality management. Factors that determine the effectiveness of the organization through continuous improvement [5].

Despite the availability of the latest version of ISO 9001:2015, Libyan firms continue to face challenges in implementing ISO 9001:2008, while the emphasis on quality management has been relatively limited, reflecting a similar trend observed in other Arabic countries [6, 7]. The scarcity of Libyan firms that have obtained ISO certification indicates a delay in accreditation. The main hurdle stems from the inadequate execution of the ISO 9001 Quality Management System (QMS) process in Libya over the past few decades. Insufficient dedicated resources and a shortage of well-trained professionals with expertise in international quality management system standards pose significant barriers to successful implementation in Libya [8, 9].. Additionally, the absence of a well-established support system and tailored guidance further exacerbates the challenges faced by Libyan companies in this domain.

This implementation gap in ISO 9001 negatively impacts the overall quality management practices in Libyan firms. It hinders their ability to meet international quality standards, impairs competitiveness in the global market, and restricts opportunities for growth and development. Addressing these issues requires a concerted effort to provide adequate resources, training, and support to enable Libyan companies to effectively implement and benefit from ISO 9001:2015 and improve their quality management practices.

3. Research Objectives

The general objective of this research is to find out the effectiveness of ISO 9001 as a mediators between Total Quality Management (TQM) and Organisational Performance (OP) among Libyan manufactories. Specifically, the objectives of the research are to:

1. Analyse the association between TQM and organizational performance by ISO 9001.
2. Determine the mediating effect of ISO 9001 between TQM and organizational performance OP.

4. Research questions

To answer the research objectives, the following questions need to be answered :

1. What is the nature of the association between TQM, ISO 9001 and organizational performance
2. Does ISO 9001 mediate the relationship between TQM and OP in the Libyan firms?

5. Total Quality Management (TQM) and Business Excellence Models (BEMs)

The Business Excellence Model (BEM) was originally called the Total Quality Management Model (TQM). Today, it is commonly stated as the Business Excellence Model (BEM). The term helps convey the meaning of 'excellence' in all aspects of a business, not just product or process quality. Traditionally, it was used to assess core values and concepts of business excellence (success factors) that are embedded and integrated into an organization. The organization uses its TQM to understand and evaluate processes that need improvement to improve results. This includes the organizational environment, key business relationships, and strategic context (competitive landscape, strategic challenges, and benefits, performance improvement systems, etc.) [10]. Business Excellence (BE) the goal is to develop and enhance an organization's control systems and processes in order to improve overall performance and create value for its stakeholders. BE does more than just provide quality systems. BE is about delivering excellence in everything an organization does, including leadership, strategy, customer centricity, information management, people and operations, and most importantly, achieving superior performance. BEM helps organizations assess

their strengths and areas for improvement and guides them on what to do next. BEM provides senior executives with a comprehensive way to run their businesses and support key decisions that lead to sustainable and measurable success. In a way, BEM acts as an organization's internal management consultant. Ensure business decisions address the needs of all stakeholders in line with organizational goals and take into account current considerations of international best practices. TQM and BEM have been the most popular in the last 20 years. Existing BEM models are often developed or supported by national agencies as a basis for the winning programmer and for the widespread adoption of his TQM principles and methods and BE [11]. According to [12], the Baldrige Excellence Framework, which stands for Baldrige Performance Excellence, enables organizations in order to achieve their goals, advance their outcomes, and become competitive. Thousands of organizations use the Baldrige Excellence Framework worldwide as their main values and concepts, standards of excellence, and evaluation guidelines to achieve and improve sustainable results. Persons acknowledged as a National Model obtain an MBNQA. Presidential prize. Over 100 receivers share their best practices with others. The purpose of the Baldrige Framework is to enable an organization or industry to answer three questions. How do you identify? What and how should your organization need to improve or change? By challenging your organization with the questions that make up the Standards for Excellence in Performance, you can find out how well your organization is achieving what is important. The seven critical aspects of the Baldrige Excellence Framework on managing and performing as an organization; [13] are as follows: (i) leadership, (ii) strategy, (iii) customers, (iv) measurement, analysis, and knowledge management, (v) workforce, (vi) operations, and (vii) results. Figure (1) shows the Baldrige Excellence Framework. It is applied in the United States but has been adopted by many countries around the world.

Figure (1): Baldrige Performance Excellence Program (2018)

TQM Elements

In the literature review, various studies have provided operational definitions of the key dimensions of Total Quality Management (TQM) to facilitate a comprehensive understanding and comparison. The dimensions commonly explored include leadership, strategy design, consumer concentration, measurement analysis, and knowledge management, workforce focus, and operation focus. These dimensions serve as critical components of TQM and are assessed to measure the degree of TQM implementation within an organization. Scholars have extensively examined these dimensions in the context of TQM, ensuring their alignment with the theoretical construct of TQM and its application in practice [14],

To assess the level of TQM implementation, this study adopts six widely accepted TQM elements: customer focus, strategic planning, leadership, knowledge management and information, operations process, and workforce. These elements have been derived from a comprehensive review of the literature and have been supported by numerous authors. They serve as fundamental pillars for successful TQM implementation and are instrumental in achieving organizational excellence. This paper adopts TQM as the theoretical framework and foundation, drawing upon the principles of the Baldrige Excellence Framework [13];[15]

6. The ISO 9001 Family of International Standards

The ISO 9001 family of international standards is developed by the International Organization for Standardization (ISO), which consists of 165 national standards bodies. ISO 9001 provides a set of standardized requirements for quality management systems (QMS) and is applicable to organizations of all sizes and sectors. The most recent version is ISO 9001:2015, which replaced ISO 9001:2008. Certification under this standard allows organizations to adopt a systematic and structured approach to managing their operations, ensuring consistent product or service quality, and meeting customer expectations**.**

ISO 9001:2015 emphasizes a process-based approach to quality management, focusing on risk-based thinking and strong customer orientation. It provides a framework for organizations to establish and maintain a QMS that drives continual improvement, prevents nonconformities, and enhances customer satisfaction. The standard places greater emphasis on leadership, organizational context, and the involvement of top management in driving quality initiatives**.**

The effectiveness of ISO 9001:2015 relies on organizations' internal motivation and commitment to quality improvement, rather than solely seeking certification as a means of demonstrating compliance. By implementing ISO 9001:2015, organizations can gain a competitive edge, enhance their operational efficiency, and improve overall customer satisfaction [16]; [17]. The standard promotes a culture of quality, continual improvement, and a proactive approach to identifying and addressing risks and opportunities in the organization.

The Effectiveness of ISO 9001 as a Mediating Variable in the Link between TQM and OP

In this discussion, the authors examine the effectiveness of ISO 9001 as a mediator between TQM and organizational performance (OP) in Libyan firms. ISO 9001 effectiveness is defined as the extent to which the expected results are achieved [18]. Analyzing the competence of an ISO 9001 QMS requires considering the organization's approach to key deliverables and understanding the influencing factors beyond quality practices. [19]. The impact of ISO 9001 on performance is hindered when there is a lack of internal enthusiasm and motivation, emphasizing the significance of seeking certification as a quality improvement approach [17].

Practical evidence supports a consensus on the underlying structure of ISO 9001 effectiveness, and the indicators used to assess its objectives are derived from research [20] ISO 9001 effectiveness directly and significantly affects product service quality and organizational performance (OP) in service companies. However, only OP has a direct impact on financial performance, with the influence of ISO 9001 effectiveness being indirect through a significant correlation with OP. The impact of ISO 9001 effectiveness on service organizations' performance in terms of market share and customer satisfaction remains uncertain. Confirming the basic structure of ISO 9001 efficiency, a study involving small and medium-sized food manufacturing companies identified three objectives of ISO 9001 (prevention of non-conformance, continuous improvement, and customer focus) [20].

7. Organisational Performance (OP)

Performance is an important variable in any organizational and job performance issues. There was an argument by [21] that success in performing a task is determined by employee performance. In other words, performance is a critical factor in success. With regard to the success of the organization, the managers need to pay attention to the OP to get the best results. OP is a measure of how successful an organization is in achieving its goals [22]. Various studies have shown that there are five types of abilities. First, individual knowledge of a particular job or specialty, second, the ability to perform physical or mental skills or performance, third, individual attitudes and values that support self-concept or self-image, and fourth, physical traits or characteristics. With a situation or information and, finally, a certain motive, idea or intent that acts as the basis and encourages the individual to act or act in a certain way [23]. They are six TQM dimensions, three ISO 9001 dimensions and four OP dimensions as the relationships between the concepts are shown in Figure (2).

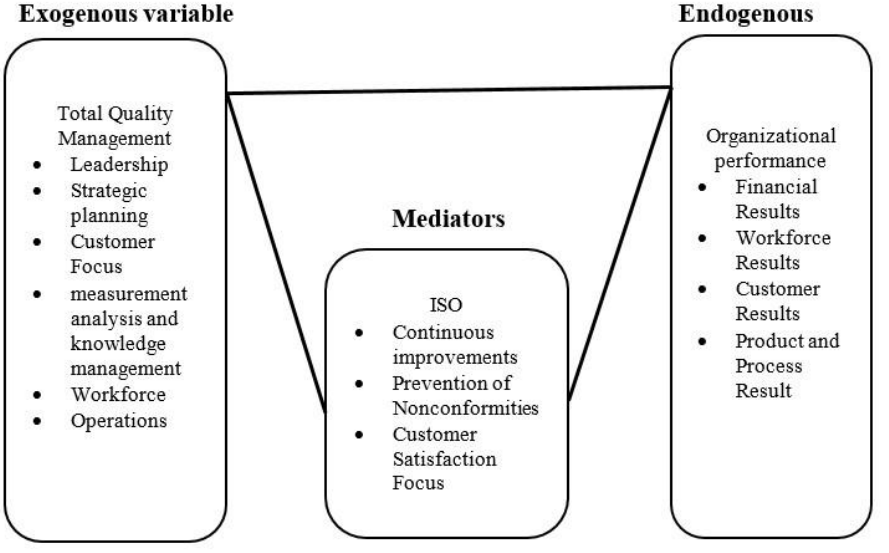

Figure (2): A Model shows the structural relationship between TQM, Effectiveness of ISO 9001 Certification, and OP

Research Hypothesis

H1: TQM implementation has a significant influence on OP.
H2: TQM implementation has a direct positive significant influence on ISO
H3: ISO effectiveness has a direct significant influence on OP.
H4: ISO 9001 certification will mediate the relationship between TQM and OP.

8. Methodology

8.1. Research Design

According to [24], research design is the specific ways involved in the research procedure: data collection, data analysis and report writing. The survey design with questionnaire was the most commonly used alternative in Production and Operation Management research. [25]Compared to other research strategies based on three conditions; the type of research questions, investigator control over behavioural events and degree of focus on contemporary issues. Both the case study and survey have no investigator control over behavioural events, and they focus on contemporary issues. The

case study answers questions related to how and why. However, the survey answers questions related to who, what, where, how many and how much. Since the current research attempted to answer such questions, survey is the preferred method. Moreover, many TQM studies have used the survey method. Based on all these considerations, a survey was used in this research to empirically investigate the proposed research model. The empirical survey was divided into two parts: a pilot survey and a final survey. The purpose of the pilot survey was to study the responses, and rectify, modify and redefine the questions for the final survey if necessary.

Research design involves planning the actual research, addressing aspects such as research paradigms, strategies, approaches, data collection methods, and data analysis techniques. All of these influence the extent to which research goals and objectives are achieved.

The theoretical framework underpinned the basis for the design of this research; the independent variable in this study is TQM in the Libya firms. The dependent variables in this study are OP. However, ISO 9001 effectiveness as a mediator. It also provided some explanations with respect to the findings of this study and compared these results to previous related studies. Additionally, it was cross-sectional in nature; in that data were collected at one point in time. [26].

Data collected through the questionnaire were analysed using the Statistical Package for Social Sciences (SPSS). SPSS is a widely used software program for statistical analysis in social sciences research. It facilitated the organization, manipulation, and interpretation of the collected data. Descriptive statistics, such as frequencies and percentages, were calculated to provide an overview of the responses. Additionally, inferential statistics, including correlation and regression analysis, were employed to examine the relationships between variables and test the proposed research model.

Structural Equation Modelling (SEM) was used to analyse the data and test the proposed relationships between TQM, ISO 9001 effectiveness, and organizational performance. SEM is a comprehensive statistical technique that enables the examination of complex relationships among variables and provides insights into the underlying theoretical model. In this research, SEM allowed for the assessment of both direct and indirect effects between the variables.

The Partial Least Square (PLS) approach was employed in this research to estimate the measurement and structural models within SEM. PLS is particularly useful when the focus is on prediction and explanation rather than testing hypotheses. It accommodates small sample sizes and is less sensitive to violations of distribution assumptions compared to other approaches. By utilizing PLS, this research aimed to assess the mediating role of ISO 9001 effectiveness between TQM and organizational performance in the Libyan firms.

Overall, the research design encompassed a survey method, the development of a questionnaire, data analysis using SPSS, the application of SEM with the PLS approach, and the utilization of a cross-sectional research design to gather data at a single point in time [26].These elements collectively contributed to the empirical investigation of the proposed research model and facilitated the examination of the relationships between TQM, ISO 9001 effectiveness, and organizational performance in the context of Libyan firms.

9. Hypotheses Testing

The PLS method to test hypotheses from both the temporal and structural models. Accordingly, a full model, which comprises the structural model for all phases, was identified, constructed and tested along with supplementary pathways to examine the temporal models beta coefficients for the model's paths. A PLS takes measurement errors into account, but not only that; it generates estimates of standardized regression coefficients. The method of PLS can be utilized to evaluate the relationship between the latent variables [27]. The relationship between the study's variables was presented and hypothesized by the structural model. The result of the direct relationship between the study variables is shown in Table 4. The study found a positive relationship between TQM and OP. The results indicated the existence of a positive TQM on OP (β= 0.180, $p<0.01$),), a significant relationship between TQM and ISO 9001 (β = 0.467.

Table 4: Testing the Direct Effect

Relationship	Beta	Std. Error (STERR)	t-value	Decision
TQM -> OP	0.180	0.069	2.606**	Supported
TQM -> ISO	0.467	0.045	10.184**	Supported
ISO -> OP	0.253	0.067	3.7873**	Supported

p<0.01), and a significant relationship between ISO 9001 and OP (β = 0.253, p<0.01). Thus, these results supported hypotheses H1, H2, H3.

9.1. Testing the Mediating Effect

Testing the mediating effect of ISO 9001 was one of the main objectives of the paper. To test the ISO of the mediating effect and testing this effect, a t-test via non-parametric procedure of bootstrapping was undertaken. With the non-parametric PLS path-modelling approach, a non-parametric bootstrapping procedure was administered to test the significance of the mediating effect as suggested by [28]. In this study, indirect relationship was found to be supported based on the hypotheses formulated; the results of the mediating effect are also shown in the summary Table 5.

Table 5: Testing the Mediating Effect

Path	Path a	Path b	Path a*b	Std. error	*t-value*	95% LL	95% UL	Decision
TQM>ISO>OP	0.467	0.254	0.119	0.035	** 3.392	0.050	0.187	Supported

9.2. Assess the Variance Accounted For (VAF)

The variance described in the VAF evaluation is performed to see how much the mediator variable is up taken. The variance with VAF in consideration determines the magnitude of the indirect effect relative to the overall effect. VAF = indirect effect/total effect. We can conclude that the VAF is less than 20% and there is little mediation. In contrast, if the VAF results are very large (80% or more), you can assume complete mediation. Cases in which VAF is greater than 20% and less than 80% may be described as partial mediation [29]. In this study, the calculated VAF was 66%, which was partially mediated.

AVF=Indirect Effect /Total Effect= a*b/ a*b + c = 0.119/0.119 +0.180=0.119/0.299=0.66, 66%.

Table 6: Assess the Variance Accounted For (VAF)

No	Path	Path a	Path b	Path a*b	Std. error	*t-value*	Rate	Level
H7	TQM>ISO>OP	0.467	0.254	0.119	0.035	3.392**	**66%**	Partial

TQM=Total quality Management; ISO= International Standard Organisation; OP =Organisational Performance

9.3. R-squared

As shown in [30], R2 provides a range of variations to endogenous constructs that are accounted for by exogenous constructs. The value of R2 increases as the number of exogenous variables increases [31]. In this study, after evaluating the metrological model, the structural model was evaluated in the following steps. First, I checked the value of each construct R2. In PLS, the R2 score represents the amount of variance of the structure of interest explained by the model. The value of R2 is important in research, and there are differences in what level of R2 value is satisfactory. According to the guidelines in [32], R2 values between 0.02 and 0.12 are weak, 0.13 and 0.25 are moderate, and 0.26 and above are significant. The R2 values for ISO 9001 and OP were found to be 0.218 and 0.163 respectively.

9.4. Predictive Relevance (Q^2)

A predictive sample reuse technique known as Stone-Geisser Q2 can be applied as a measure of predictive significance, unlike determining the size of R2. This technique represents a combination of cross-validation and functionality in the light that predicting possible observations or observations is more relevant than estimating synthetic configuration parameters. [33] He also emphasized using this measure to assess the ability of research models to make predictions. Taking this approach in PLS ensures a blind procedure that removes some data within a given indicator block during parameter estimation and tries to estimate the omitted part using the estimated parameters [34]. Based on the blindfold procedure, Q2 assesses the predictive validity of the model via his PLS.Q^2 is generally estimated using an omission of distance of 5 - 10 in PLS [35] Q^2 values larger than zero indicates that the exogenous constructs have a predictive relevance for the endogenous construct [36]. The summary of the predictive relevance has been outlined in Table 7, showing R^2 and Predictive Relevance respectively.

Table 7: Result of Predictive Relevance (Q^2) and R-squared (R^2)

Predictor	Endogenous	Beta	Q^2 (CV Red)	R^2	Level
TQM	ISO	0467	0.108	0.218	Moderate
TQM	OP	0.180	0.087	0.163	Moderate
ISO		0.254			

TQM=Total quality Management; ISO= International Standard Organisation; OP =Organisational Performance

9.5. Recapitulation of the Findings

This study focuses on the implementation of total quality control in Libya's industrial sector, which plays an important role in the course of Libya's economic and social development. However, to succeed in the global market, the sector needs to learn from successful organizations around the world and improve its operations. Comprehensive quality control practices in Libya's industrial sector have proven vital to its survival and growth. The aim of the current study is to examine the effect of his TQM on the OP of a Libyan manufacturer. This study tested the effectiveness of ISO 9001 as an intermediary in the relationship between TQM and OP. The purpose of this study is to examine the relationship between TQM and OP through ISO 9001 as a facilitator of a manufacturing company in Libya. Here are some questions that will help you reach your research goals.

9.6. Does ISO 9001 mediate the relationship between TQM and OP in the Libya firms?

It turns out that ISO 9001 has a positive and significant relationship between TQM and OP among Libyan manufacturers, and as a result, ISO 9001 is considered as ISO as a tool that can be implemented within the context of TQM implementation. . 9001 is highly rated as a set of standards regulated to improve an organization's level of quality. This relationship illustrates the importance of ISO 9001 as an intermediary between TQM and OP, which can lead to improved performance and productivity. Most importantly, ISO 9001 is globally recognized because it is certified, which means that the company is moving towards globalization and implementing Total Quality Management. Its main goal, it is widely claimed, is to

harmonize standards around the world that can enhance trade and contribute to the efficiency of global welfare. In general, the impact of QMS ISO 9001 on organizational performance is the improvement of product quality for these manufacturers, so in terms of product quality and quantity, there is an impact of QMS ISO 9001 on OP improvement.

9.7. The Relationship between TQM and OP

Two tests were made in order to measure the relationship between TQM and OP, namely the direct effect between TQM and OP without mediating and the direct effect with mediating. The direct effect without mediating showed a positive significance relationship between TQM and OP, and the direct effect with mediating between TQM and OP showed a positive relationship between TQM and OP. As a result, both have indicated a positive significance relationship between the TQM and OP. This is similar to the findings from [37]. TQM is beneficial in order to improve quality, as the implications of TQM and practices work positively in improving the organisational performance [38].Study [5] also demonstrated a focus on the four dimensions of TQM. Customer focus, continuous improvement, and employee and senior management engagement help identify the most important quality aspects of an organization's performance predictions.

9.8. The Relationship between the TQM and ISO 9001

Tests have been conducted to measure the relationship between TQM and ISO 9001, and the results have shown a positive and significant correlation. These findings confirm that a strong TQM system requires a thorough understanding of internal processes. ISO 9001 adopts a structured approach to managing business practices and offers a proven framework for consistently producing high-quality products**.** TQM is more than just a philosophy [39]; it encompasses a comprehensive system of principles, methodologies, and practices that aim to achieve continuous improvement and customer satisfaction. ISO 9001 certification serves as a vital marketing tool, signifying official recognition that a company adheres to and implements its own quality management system. With its global recognition, ISO 9001 certification allows companies to expand their reach and establish a presence in international markets. Certification is granted and validated by an independent third-party entity, ensuring reliability. It also provides

information on the type and extent of TQM practices and accreditation history, serving as a reference point for comparison and evaluation.

9.9. The Relationship between the ISO 9001 and OP

The relationship between ISO 9001 and OP showed a positive and significant relationship between ISO 9001 and OP. This result was confirmed in a case similar to that shown by the study by [40] .ISO 9001 contains significant research focusing on the relevant effects of motivation and the implementation process on ISO 9001 and OP.

According to [41], quality standards have a positive relationship with operational and implementation performance. [42] It was reported that QMS ISO 9001 has the effect of improving organizational performance in terms of product quality and quantity. It is said that this is the impact of QMS ISO 9001 on the performance of the organization because the quality of the products is improving in the organization that has been awarded the ISO 9001 Quality Management System Certification. Actively contribute to the performance of your organization. Therefore, Libyan manufacturing can improve its ability to improve performance and ensure optimal results.

9.10. ISO 9001 Mediating the Relationship between TQM and OP.

The indirect effect of the TQM and OP through the ISO 9001, revealing the mediating relationships was one of the significant objectives of this study, by examining whether the ISO 9001 mediates the relationship between the TQM and OP. Accordingly; it was found the impact of TQM on operational processes was found to be superior to the Libyan manufacturers with ISO 9001 certification. The mediating relationship between TQM and OP through ISO 9001 was supported by the findings from [43] who indicated that ISO 9001 has influenced organisational performance through a number of factors, which can be considered as a mediator between TQM and Organisational Performance. As the companies that are certified with ISO 9001 usually have higher performance than their non-ISO certified counterparts, it shows that there is a positive relationship for the ISO 9001 as a mediator between TQM and OP in accordance with the justification for the adoption of ISO 9001 standard in the manufacturing companies since the ISO 9001 certified companies will enhance their quality management practices to achieve the objectives being set by these companies.

10. Conclusion

It can be concluded that this study focuses specifically on the implementation of TQM in the Libyan industrial sector. Libya's industrial sector not only plays an important role in Libya's economic structure and growth rate, but also in its social development. The purpose of the research was to study the impact of his TQM on OP in the Libyan manufacturing industry. The effectiveness of ISO 9001 as a mediator in the relationship between TQM and OP was tested. An analysis of the study showed results consistent with the Baldrige Performance Excellence program, confirming six key dimensions of organizational management and performance. As a result of measuring the relationship between TQM and OP as a direct effect, a positive and significant relationship was shown. As a result, it was found that the relationship between TQM and ISO9001 shows a positive relationship

It is hoped that the results of this empirical research will help Libyan companies implement his TQM practices and improve organizational performance in the future. We hope that the results will serve and serve as a guide for compliance managers and manufacturing personnel in Libya to improve their organization's performance through his TQM. Information for future research includes length of time or level of commitment to both TQM and ISO 9001. A limited number of KPIs were explored in the current study. It is therefore worth considering the implications of applying TQM to other potential operational policy instruments. Further research on Libyan manufacturers will open the door for raising quality levels and TQM for improving performance.

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Effect of curing time on strength development of alkali-activated clayey soil reinforced with Polypropylene fibers

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الملخص

في بعض التطبيقات الهندسية لا يمكن لصلابة التربة وحدها أن تكون معيارا موثوقا به عند التعامل مع التحميل الديناميكي . بمعنى آخر، يجب تحسين مرونة التربة المكونة للأساسات من أجل منع الضرر المفاجئ بسبب هشاشتها . العديد من البحاث اهتموا بدراسة تدعيم التربة بواسطة الياف البوليبروبلين. من ناحية أخرى هناك طريقة جديدة تستخدم لتحسين الصلابة لدي التربة الناعمة تسمى بطريقة التفاعل القلوي لمادة الفحم المتطاير والتي فيها يضاف محلول هيدروكسيد البوتاسيوم لإنتاج ماد شبيهة بالإسمنت من ناحية الصلابة. علاوة على ذلك توجد تجارب حديثة جدا دمجت الطريقتين سالفتي الذكر لتحسين الصلابة والمرونة لدى التربة الطينية في آن واحد. في هذا البحث تم إجراء اختبار مقاومة الانضغاط لعينات محسنة قلويا 40SF واخري محسنة قلويا ومدعمة بألياف البوليبروبلين 0.75SFR بعد أن تعرضت للمعالجة الكيميائية في أكياس حافظة للرطوبة لمدة 28 و 90 يوما. أفضت النتائج المستخلصة من البحث بأن العينات المحسنة قلويا قد اكتسبت صلابة عالية جدا مقارنة بإجهاد التحميل للتربة الأصلية S والذي يقدر ب 190 kPa, متمثلة في 3680 kPa و 18500 kPa لمدة 28 و 90 يوما على التوالي مع تعرض العينات للكسر الفوري عند بلوغ اجهاد التحميل. مع إضافة ألياف البوليبروبلين التدعيمية للعينات المعالجة كيميائيا لمدة 28 و 90 يوما تغير

وضع الانهيار عند إجهاد التحميل من وضع هش جدا إلى وضع أكثر مرونة بسبب إجهاد الشد المنتقل من ألياف التدعيم إلى التربة.

Abstract

In some engineering applications soil stiffness only could not be a reliable parameter in accordance with specific standardizations especially, when dealing with dynamic loading. In other words, foundation soil should be altered regarding its ductility in order to prevent sudden damage due to brittleness. Plenty of researchers have studied the effect of multifilament polypropylene fibers on soil reinforcement. Besides, the alkaline activation method has been adapted to alter the strength properties of soft soil. Furthermore, in a cutting edge method, alkaline activation of soft soil, using fly ash and Potassium hydroxide, coupled with soil reinforcement was adapted to change the post-peak behavior of soft soil. The goal of this novel technique is to increase the ultimate strength and to enhance the failure mode. In this research work alkali activated kaolin soil and alkali-activated reinforced kaolin soil were cured for 28 and 90 days respectively. Compressive stress tests were conducted on both mixtures, namely, SF40 (Soil +40% fly ash) and SFR0.75 (Soil+ 39.7% fly ash + 0.75% PP fibers) samples. Results drawn from the tests revealed a drastic increase in Compressive strength for SF40 samples cured for 28 and 90 days, namely, 3680 kPa and 18500 kPa, respectively. Whereas, the strength recorded by the control sample was only 190 kPa. Though a sharp drop was seen when approaching failure. The addition of reinforcing Polypropylene fibers brought about a drastic enhancement in failure mode for both of curing regimes.

Keywords: Soil stabilization; Polypropylene fibers; Alkali activation; Compressive strength; Curing regime

Introduction

The use of fly ash-based geopolymers in the field of soft soil engineering has made significant strides in the last ten years. The viability of using a fly ash-based binder for soil remediation has been demonstrated in numerous investigations. This research has demonstrated that using fly ash binders increases the treated soils' stiffness and durability [1-7].

Despite increasing the stiffness of the treated soil, alkaline-activated soils have a very brittle failure mechanism. This is consistent with the outcomes seen in soils treated with cement and lime, where the cementitious agent is present in the form of ASH(Aluminum Silicate hydrate) or CSH (Calcium Silicate hydrate), respectively, leading to high strength values [8-11]. Due to the soil's brittleness, a soil column that is exposed to seismic loads or lateral earth pressures will crack and collapse under tension [12-13].

In addition, numerous studies have looked into how polypropylene fibers affect the mobilization of tensile strength between soil particles that have been cemented. These investigations have found that polypropylene fibers are effective in preventing crack spread in concrete and cemented soils, resulting in higher residual strengths [13-15]. Additionally, Elkhebu Ahmed et, al [16-17] has developed a novel method to modify the ductility characteristics of soft soil. In this case, soft soil and polypropylene fibers were combined while being subjected to an alkaline activator. Compressive strength tests were performed after the samples had been cured for 28 days. The conclusions reached indicated a better ductile failure mode. The current study explore the effect of prolonged curing time on strength development of treated soil. The curing period was suggested to be 90 days to allow for the effect of geoplimezation and polypropylene fiber mobilization on ductility and strength evolvement.

Experimental Program

Material

Malaysia's Kaolin Company in Puchong/Kuala Lumpur provided the soil that was used in the current investigation. As seen in Fig. 1, its reddish-brown color indicates an undamaged platy structure. It is important to note that the host soil does not lend itself to being used to create soil layers for building since it has a low strength and a high plasticity index, making it a high-plasticity clay according to ASTM D2487 [18]. Table 1 lists the clayey soil's physical characteristics. Table 2 lists the fly ash's chemical composition as determined by Energy Dispersive X-ray Fluorescence (EDXRF). The electric power station (Kapar) Selangor supplied fly ash class F (Fig. 2). This

precursor has a high alumina and silica content, which is expected to enhance the alkaline activation processes, as can be observed from the chemical analyses in Table 2.

Fig. 1. Host clayey soil

Fig. 2. Fly ash

Table 1 Physical characteristics of host soil

Basic soil property	Standard	Value
Specific gravity (GS)	BS 1377-2	2.58
Liquid limit (LL) (%)	BS 1377-2	73%
Plasticity index (PI) (%)	BS 1377-2	30
OMC (%)	BS 1377-4	30
MDD (Mg/m^3)	BS 1377-4	1.3
UCS (kPa)	BS 1377-7	190

Table 2 Chemical analysis of soil and fly ash

Constituent	Natural soil (%)	Fly ash (F) (%)
Silica (SiO2)	38.622	42.873
Alumina (Al2O3)	28.311	16.057
Iron oxide (Fe2O3)	26.854	20.559
Calcium oxide (CaO)	-	8.888
Potash (K2O)	3.522	3.951
Titanium Dioxide (TiO2)	1.972	2.949
Sulfite (SO3)	0.406	0.751

In a recent experiment, Ahmed Elkhebu et, al [16-17] showed that effective compressive strength values were achieved using 40% fly ash (by dry weight of soil+fly ash combinations). KOH (Potassium hydroxide) pellets as illustrated in fig.3 were supplied by R&M Chemical. According to Alsafi et, al

[19], the KOH (Potassium hydroxide) pellets were dissolved in distilled water a day before testing to create a solution with a predetermined concentration of 12 Mol. Timuran Engineering Sdn Bhd Malaysia provided polypropylene multifilament fibers (Fig. 4) for the purpose of reinforcing. Their tensile strength, resistance to alkaline environments, and other details are listed in Table 3. They are excellent candidates for soil enhancement because of these qualities.

Fig. 3. KOH pellets

Fig. 4. Multifilament polypropylene fibers

Table 3 Specifications of PP multifilament fibers

Properties	Value
Length	12 mm
Mass (Denier)	15 denier
Specific gravity	0.9 g/cm^3
Aspect ratio	Nil
E-Modulus	3500 N/mm^2
Tensile strength	400 N/mm^2
Tensile at break	35 N per 1000 denier
Elongation at break	15%
Chemical composition	C-33%, H- 67%
Melting point	160 - 170°C
Acid & alkaline resistivity	High

Provided by Timuran Engineering Sdn Bhd

Malaysia

1.1 Mixing method

According to Ahmed Elkhebu et, al [16-17], the clayey soil was mixed with fly ash at a rate of 40% in order to achieve the fastest strength evolution rate. To allow for alkali reactions and PP fiber mobilization, 28 and 90-day curing periods were adapted. According to Ahmed Elkhebu et, al [16-17], polypropylene fibers of 0.75 percent were also taken into account in this study to enable optimal mixing and compaction. In order to guarantee a uniform distribution, the fly ash was first put into the oven-dried soil and carefully mixed. According to Ranjbar et al. [20], PP fibers were dipped in KOH solution and added to the mixture to prevent mixing up and ensure adequate dispersion. One should be aware that the interaction between KOH pellets and pure water leads to heat development. KOH solution should therefore be ready a day before testing operations. Sample type, curing schedule, and compressive strength testing are displayed in Table 4.

Table 4 Group series, Samples, Curing regime and Type of testing

Group series	Test number	Samples	UCS test, curing (days)+ Number of tested specimen
S	S	Natural Soil	(3)
SF	SF40	12MKOH + 40% Fly ash+ 60% Soil	28, 90 (6)
SFR	SFR0.75	12MKOH + 39.7% FA, 59.55% S, 0.75%PP	28, 90 (6)

Unconfined Compressive Strength

As previously indicated, to achieve the intended OMC and MDD, according to Abdullah, Shain and Sarker [6], the cool KOH solution was added to the soil fly ash mix at a preset optimal moisture level similar to that of a 40% fly ash soil mixture. In the current studies, 26% of the combination (soil plus 40% fly ash) is OMC. In other words, 260 mL KOH was applied to 1 kg of the soil fly ash mix, and further water was added to attain the predetermined OMC by matching the KOH content. In the second series of tests, polypropylene fibers were added to fly ash soil mixes at a solid content of 0.75% by first being immersed in a KOH solution. The specimens are then uniformly compressed in three equal layers in a cylindrical steel mold (50 mm in diameter and 100 mm in height) using a manually driven 45 mm steel rod to apply static stress brought on by 27 drops. The specimens were then tightly wrapped in aluminum sheets and polythene covers to stop moisture loss. The current investigation modified the 28- and 90-day room temperature curing regimens used by Alsafi et al. [19] Pourakbar [21] and. It should be mentioned that while polypropylene fibers are regarded as hydrophobic and do not exhibit any attraction for water, their influence on the compaction parameters is minimal. According to Malekzadeh and Bilsel [22] and Senol [23], their impact is limited to a negligible MDD reduction rate. For all soil fly ash,

polypropylene fiber combinations, a similar OMC to that of soil fly ash mixtures is therefore implemented. A day before testing, all of the treated soil samples were immersed in water to counteract the beneficial effects of suction.

According to the established standard [24], the unconfined compressive strength (UCS) measurement was done. For the sake of repetition, three specimens were used for the UCS measurements, and the findings were only acceptable if the difference from the average was less than 5%. These tests were conducted on an Instron 3382 universal testing machine that was equipped with a 100 kN load cell. Each test yielded the whole stress-strain curve and was conducted under monotonic displacement control at a rate of 1 mm/min. All specimens were kept after shearing for subsequent mineralogical investigation.

Results and Discussion

The connection between stress and strain for combinations of S, SF40, and SFR 0.75 is presented in Fig. 5. As can be shown, compared to the UCS of 190 kPa reported by host soil after 28 days, both alkali-activated and reinforced alkali-activated soil showed a significant improvement in compressive strength. For SF40 and SFR0.75, respectively, the compressive strength values were measured at 3680 kPa and 6450 kPa. This result is consistent with the findings of Cristelo et al. [1] and Tang et al. [25], who reported that a ratio of 40% fly ash to soil and fly ash contributed to the best compressive strength and that polypropylene fibers increased the strength increment rate of the cemented soil matrix, respectively. Although the incorporation of fibers increased residual strengths observed with fiber content as much as 0.75%, indicating a more progressive decline after failure, the failure mode recorded by SF40% was exceedingly brittle. Furthermore, the alkali-activated soil samples cured for 90 days exhibited a major increase in compressive strength marking a value of about 18500 kPa. However, the failure mode experienced was brittle at a strain rate of only 1.1%. This was in agreement with the results confirmed by Kamaruddin, et al. [26], after 90 days curing regime, observed a strength value of 10900 kPa for reinforced soil treated with an alkaline activator. On the other hand with the inclusion of fiber content of 0.75% the failure mode was improved recording a strain rate of 2.2%, Though a reduction in strength, due to shrinkage porosity, was

observed namely 13500 kPa. Nevertheless, this was two times greater than that value recorded for SFR0.75 cured for 28 days.

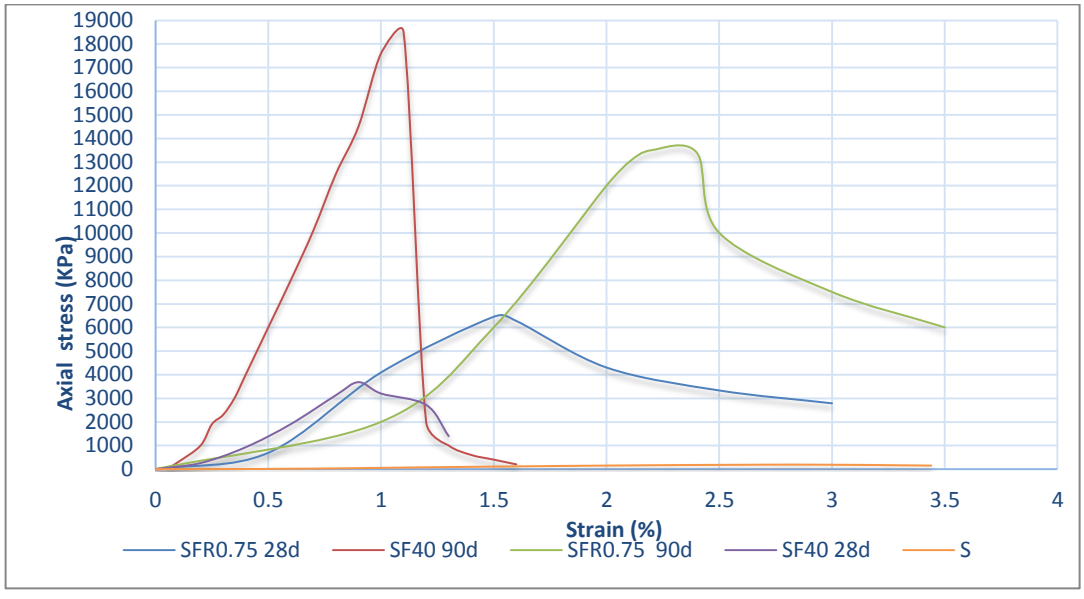

Fig. 5. Stress-strain behavior of natural soil, alkali activated- and

alkali activated reinforced soil samples after 28, 90 days curing regime

Alkali-activated fly ash was added to the naturally clayey soil, and a notable improvement was noticed. This explains why vitreous alumina on the surface of the fly ash particle immediately dissolves and absorbs the potassium hydroxide solution. In addition, a strong rise of 18500 kPa was seen after 90 days, which is five times more than that value recorded by the treated sample cured for 28 days. This was attributable to the existence of Si species in the internal entity of fly ash and its accompanying poor dissolving rate. Si bonds, therefore, control the increase in strength. These results support the judgment made by Abdullah et al. [27]. For SF40 samples that had been cured for 28, and 90 days, respectively, a corresponding strain of less than 1% and 1.1% indicated that strength was approaching failure. Therefore, polypropylene fibers were added to the pretreated alkali-activated soil to enable increased residual strength and better post-peak tendency.

The findings for the 28-day-cured reinforced sample showed a notable PP fiber impact on the mechanical characteristics of the pretreated alkali-activated soil. In other words, a considerable rise in the post-peak strength was seen for the treated sample cured for 28 days as a result of the interfacial link created between the latter and the soil gel matrix. Indicating that the polypropylene fibers were successful in transferring the shear strength between the soil particles to a tensile strength, which allowed for even higher residual strength at strain rates greater than 1.5%, the matrix becomes stronger as it approaches failure. These data concurred with Tang et al. [25] conclusion that fiber inclusion and the compressive strength of cemented soil exhibited a proportionate relationship. Although a reinforced sample that had been cured for 90 days showed a considerably greater propensity toward ductility of 2.3%, a notable drop in strength was detected, primarily because of shrinking porosity between the fiber and the treated soil alkali matrix. These findings are fairly consistent with those made public by Ranjbar et al. [20].

Conclusion

From the results of this study, the following can be concluded:

- A great deal of fly ash impact on the compressive strength of SF40 was observed. The samples cured for 28 days displayed a value of 3680 kPa. In addition, after a prolonged curing regime of 90 days, a compressive strength of 18500 kPa was recorded. This was due to the low dissolution rate of silicate bonds that have built a cemented cluster with host soil and Potassium hydroxide.
- The impact of prolonged curing regime of 90 days was obvious bringing about a 500% strength enhancement rate when comparing to that of 28 days cured sample. However, with either a lower or higher strain rate, both of alkali-activated soil mixtures indicated a sharp drop when reaching failure.
- Throughout the 28-day curing regimens, a sharp increase in the strength evolution of SFR0.75 samples was seen, with a strength increment rate of 1.8 times that of the pretreatment specimen. The interaction between cemented clusters and PP fibers brought about an increase in compressive strength. As a result, the peak value of the pretreatment specimen was

nearly doubled. In a controversial finding, compressive strength was decreased for SFR0.75 after a 90-day treatment. Due to prolonged curing, it was expected that the porosity between the cemented clusters and polypropylene fibers would diminish.

- The effectiveness of a prolonged curing regime of 90 days was incredibly high. Nevertheless, this is not practical for engineering applications.
- A novel technique should be elaborated on how to speed up the geopolymer reactions, thus allowing for field construction to be carried out in a short-defined plan.

Acknowledgment

The authors express their grateful thanks to the University of Garian, Libya.

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EVALUATION OF THE HOURLY DIRECT SOLAR, DIFFUSE AND GLOBAL RADIATION INCIDENT ON TILTED, HORIZONTAL AND VERTICAL SURFACES OVER TRIPOLI

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الخلاصة :

في هذه الورقة تم تقييم الإشعاع الشمسي الحراري المباشر و المنتشر و الكلي (global) على مدينة طرابلس و مدى تأثير زاوية الميل, تحت ظروف مناخية مناسبة خالية من الغيوم و الظلال و الغبار . الدراسة تتضمن محاكاة ثلاثة سطوح, أفقية و عمودية و مائلة, باعتبار تأثير الإشعاع الشمسي المؤسس على أن السماء صافية. حيث تم الحصول على نتائج باستخدام نموذج رياضي (ASHRAE Model) طُور باستعمال برمجة لغة فورتران90 على أساس عرض مقدم في صورة أنماط و مخططات (graphs and patterns) توضح المتوسط الشهري للإشعاع الشمسي الساعي الساقط على سطح أفقي و عمودي و مائل بدرجة 35^0 , و الإشعاع المباشر الساعي عند زوايا مختلفة وذلك لأربعة أشهر, يناير الذي يمثل فصل الشتاء, أبريل الذي يمثل فصل الربيع, يوليو الذي يمثل فصل الصيف و أكتوبر الذي يمثل فصل الخريف, وقد تم أخذ القيمة المتوسطة لكل شهر. حيث يُلاحَظ من النتائج أنه قد تم الحصول على أعلى إشعاع شمسي مباشر للسطح المائل بزاوية 35^0 عند أفضل الظروف W/m^2 1025 لشهر أكتوبر, و للسطح الأفقي $911W/m^2$ لشهر أبريل, و للسطح العمودي $791W/m^2$ لشهر يناير, أما الإشعاع الشمسي المنتشر فللسطح المائل بزاوية 35^0 , $224W/m^2$ لشهر يوليو, و للسطح الأفقي كذلك شهر يوليو $118\ W/m^2$, و للسطح العمودي $175W/m^2$ لشهر أبريل, كذلك يقال بالنسبة لإشعاع الشمسي الكلي للسطح المائل بزاوية 35^0 عند أفضل الظروف $1195W/m^2$ لشهر أكتوبر, و للسطح الأفقي $1001W/m^2$ لشهر أبريل, و للسطح العمودي $917W/m^2$ لشهر يناير, عند نفس الظروف. أما زاوية الميل للإشعاع الشمسي المباشر في أفضل الظروف°55 لشهر يناير, و°10 لشهر أبريل, و°0 لشهر يوليو, و°45 لشهر أكتوبر عند نفس الظروف, و كما يلاحظ أيضا من النتائج أن الإشعاع المنتشر له قيمة معينة في بداية النهار و آخره أي في الساعات الأولى و الأخيرة من اليوم, بخلاف الإشعاع المباشر, هذا وبشكل ملحوظ ذو أهمية كبيرة من حيث الحسابات الشمسية. إن النتائج المعروضة في هذه الورقة مفيدة يمكن تطبيقها على أرض الواقع بهدف استخدام ألواح الخلايا الفوتوفولتية للحصول على الطاقة الكهربائية اللازمة لتغذية الأحمال المطلوبة ,كذلك استخدامها في حساب طاقة التبريد للمباني، تمّ الاعتماد على بعض البيانات الخاصة مثل :الارتفاع عن سطح البحر h، و زاويتي خط العرض(ϕ) وخط الطول(L)، و زاوية المنحدر(β), و زاوية قوس السماء للسطح المدروس$^o0$ (γ).

Abstract

This paper has evaluated the direct, diffuse, and global thermal solar irradiance incident on tilted, horizontal and vertical surfaces over Tripoli city, and what is the extent of the influence the slope angle, under suitable climatic conditions on the basis of clear days and dust, dirt, trees and shading that have a negligible effect. Where, the geographical location and climatic conditions play a major role in improving the performance of solar systems. The study includes simulation of three surfaces inclined, horizontal and vertical, considering effect of solar radiation based on the clear sky. Results were obtained using a mathematical model (ASHRAE Mode) developed utilizing the programming language Fortran 90 on the basis of a presentation presented in the form of graphs and patterns showing the monthly average of the hourly direct solar, diffuse and global radiation incident on tilted, horizontal and vertical surfaces and the direct solar radiation on tilted surfaces as function of sloped angle (β) during the daylight hours for four independent months January which represented wintertime, April represented springtime, July represented summertime and October autumn time of the year.

Results show that the higher value of the hourly direct solar radiation for the titled surface 35^{o} was, 1025 W/m2 for the month of October, horizontal surface, 911W/m2 for April, and a vertical surface, 791 W/m2 for January, and with regard to the hourly diffuse solar radiation for titled surface 35^{o} , 224 W/m2 for month July, horizontal surface, 118W/m2 for July, and a vertical surface, 175W/m2 for April, also with regard to the hourly global solar radiation for titled surface 35^{o} , 1195W/m2 for month October, horizontal surface 1001W/m2 for April, and vertical surface 917W/m2 for January at the same conditions. Furthermore, the optimal tilt angle for direct solar radiation in January almost was 55°, in April the optimal tilt angle was 10°, in July the optimal tilt angle was 0° and in October, the optimal tilt angle is 45°. It can be noticed from the results that the hourly diffuse solar radiation has a certain value in the first hours of daytime and the last hours, unlike the beam solar radiation; these signs are an evident significance with regard to the Solar Radiation Calculations. However, this study results are useful and satisfactory; they can be applied in reality, with a view to using Photovoltaic Systems to get the necessary electrical energy for the requested load supply. Also, for purpose calculations of the cooling loads and the solar collectors' performance.

1. INTRODUCTION

The earth is receiving quite large amounts of energy in the form of solar radiation almost average $8 \times 10^{16}\ W$. This amount may exceed about 10000 times of the present world needs of the energy. For this reason, study and estimation amount of the hourly total (global) solar radiation is very important, since it quite useful for calculations of cooling load, solar collectors' performance and Photovoltaic systems. The solar radiation incident on earth's surface is not simple procedure; because it depends on a lot of variables and the factors like the sun's rays beyond the earth's atmosphere, the solar energy that diffuses within reason impact solar irradiance with particles atmospheric air, the solar angles changes simultaneously and local etc. Where, can't control amount the solar radiation which reaches to earth's surface. That is why it is, changed continuously as result for several effects the more important which called fundamentals Solar Components.

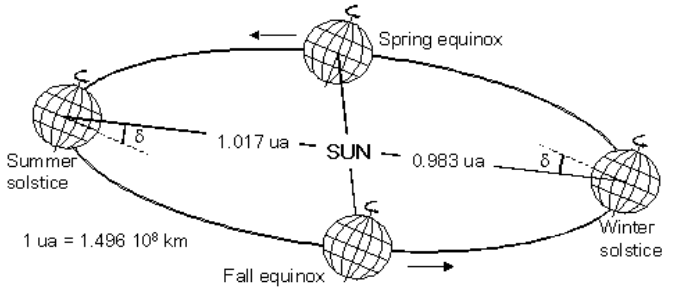


Figure (1) Maximum and minimum value of declination angle[4].

1.1. Basic Solar Components

Solar Constant (G_{SC}), the mean solar constant G_{SC} is the rate of irradiation on the surface normal to the sun's rays beyond the earth's atmosphere and the mean earth-sun distance. Extraterrestrial radiation is given by (1) [5].

$$G_{ext} = G_{SC}\left(1 + 0.33\cos\left\{\frac{360\ N}{365}\right\}\right) \quad (1)$$

Where G_{ext} Extraterrestrial radiation and N is the day of the year and G_{SC} is solar constant, 1367 W/m2.

Angle of incidence (θ), the angle between the beam radiation on a surface and the normal to that surface.

$$\cos\theta = \sin\delta \sin\emptyset \cos\beta - \sin\delta \cos\emptyset \sin\beta \cos\gamma + \cos\delta \cos\emptyset \cos\beta \cos\omega + \cos\delta \sin\emptyset \sin\beta \cos\gamma \cos\omega + \cos\delta \sin\beta \sin\gamma \sin\omega \quad (2)$$

ϕ is the location latitude angle (in degrees) and δ is the declination angle of the sun (in degrees) given by:

$$\delta = +32.45 \ sin\left(\frac{N-81}{370} \times 360\right) \quad (3)$$

N: The number of day in the year

$$\sin\alpha_s = \cos\delta \cos\emptyset \cos\omega + \sin\delta \sin\emptyset \quad (4)$$

$\boldsymbol{\alpha_s}$ is Solar altitude angle .It between the horizontal and the line to the sun, that is, the complement of the zenith angle.

$$\omega = 15^O(LST - 12) \quad (5)$$

ω is Hour angle The angular displacement of the sun east or west of the local meridian due to rotation of the earth on its axis at 15◦ per hour; morning negative, afternoon positive. As prescribed in Figure 2 [5].

Local solar time (LST) is given by the following relationship

$$LST = LT + {}^{TC}/_{60} \quad (6)$$

If daylight savings time, hours (DST) is in effect,

Local Standard Time = Local DST – 1hour {Daylight saving is on}

Local DST= local daylight savings time, hours

Where LT is the local standard time for the studied zone in hours and TC time correction factor in munities is given by eq. (7):

$$TC = 4(L - LSTM) + EOT \quad (7)$$

Where L geographical longitude for the studied zone in degrees and LSTM represented the standard meridian for local time given by the following relationship

$$LSTM = 15(\Delta T_{GMT}) \quad (8)$$

ΔT_{GMT} :The difference between local time of the studied area and Greenwich Mean Time in hours

EOT : Equation of time in munities is calculated by eq. (9):

$$EOT = 9.87 \sin 2D - 7.53 \cos D - 1.5 \sin D \quad (9)$$

D: Constant magnitude and function of number of day in the year can be expressed as eq. (10):

$$D = \frac{360}{365}(N - 81) \quad (10)$$

2. ASHRAE Clear Sky Model

The ASHRAE algorithm offers a simpler method, which is widely utilized by the engineering and architectural communities [6]. The value of the solar constant does not take into account the absorption and scattering of the earth's atmosphere. Several types of radiation calculations are most conveniently done using normalized radiation levels, that is, the ratio of radiation level to the theoretically possible radiation that would be available if there were no atmosphere. For these calculations, which are discussed in next item, we need a method of calculating the Global Solar Radiation on Horizontal, vertical and tilted Surfaces.

At any point in time, the solar radiation incident on a plane inside of the atmosphere is the normal direct solar radiation and the diffuse.

2.1. Radiation on tilted surfaces

The calculation of the radiation over a tilted plane requires determining the sun position together with the slope and orientation of the tilted plane. The plane angles are defined as follows (see Figure 2). β is the slope of the surface, measured from the horizontal plane towards the equator. γ the surface azimuth angle and it measures the orientation of the surface from the local meridian, east positive. θ is the angle of incidence of radiation, that is, the angle between the normal to the surface and the sun earth vector.

Thus, the cosine of the incidence angle θ between the sun beam radiation and a surface tilted an angle β towards the equator, oriented in any direction γ, is given by [5]:

$$\cos\theta_\beta = \sin\delta\sin\emptyset\cos\beta - \sin\delta\cos\emptyset\sin\beta\cos\gamma + \cos\delta\cos\emptyset\cos\beta\cos\omega + \cos\delta\sin\emptyset\sin\beta\cos\gamma\cos\omega + \cos\delta\sin\beta\sin\gamma\sin\omega \quad (11)$$

For vertical surfaces, $\beta = 90^\circ$ and the equation becomes

$$\cos\theta_V = -\sin\delta\cos\emptyset\cos\gamma + \cos\delta\sin\emptyset\cos\gamma\cos\omega + \cos\delta\sin\gamma\sin\omega \quad (12)$$

For horizontal surfaces, the angle of incidence is the zenith angle of the sun, $\theta_H = \theta_Z$. Its value must be between 0◦ and 90◦ when the sun is above the horizon. For this situation, $\beta = 0$, and Equation 2 becomes:

$$\cos\theta_H = \sin\delta\sin\emptyset + \cos\delta\cos\emptyset\cos\omega = \sin\alpha_s \quad (13)$$

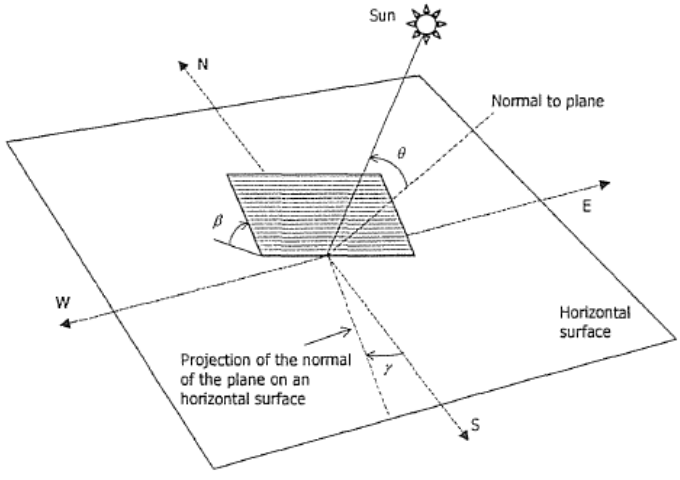


Figure 2. Definition of angles for the incidence of solar radiation on a tilted plane [9].

2.2. Hourly Global Solar Radiation on Horizontal Surfaces (IG_t)

Global solar radiation on horizontal surfaces can be measured with a pyranometer, which is an instrument that measures global solar radiation from all directions. The global solar radiation on horizontal surfaces can be categorized as follows:

- Diffuse solar radiation (IF)
- Direct beam solar radiation (IB)

Solar radiation on a horizontal surface is the sum of the horizontal direct and diffuse radiation.

$$IG_t = IB + IF \tag{14}$$

IG_t= Global Solar Radiation, Btu/(hr-ft^2) or (W/m^2)

IB= Direct beam solar radiation, Btu/(hr-ft^2) or (W/m^2)

IF= rate at which the total diffuse radiation (reflected plus diffuse), Btu/(hr-ft^2) or (W/m^2)

$$IF = Id + \text{Ir} \tag{15}$$

Id = rate at which energy is diffused on to sky (isotropic sky), Btu/(hr-ft^2) or (W/m^2)
Ir = rate at which Energy reflected from ground and surroundings (diffuse reflection), Btu/(hr-ft^2) or (W/m^2)

- **Normal direct irradiation**

$$Ib = \frac{A}{EXP\left(\frac{P_L \quad B}{P_O \sin \alpha_S}\right)} C_N \tag{16}$$

$$\frac{P_L}{P_O} = exp(-0.000184\, H\,) \tag{17}$$

Ib = normal direct irradiation, Btu/(hr-ft2) or (W/m2)[3]
αs = solar altitude
C_N = clearness number equal 1.0
$\frac{P_L}{P_O}$= ratio between atmosphere pressure at the studied site and the standard atmosphere pressure as function in altitude [8].
H = the altitude of the observer in kilometers

$$A = 1158\left[1 + 0.066\ \cos\left(\frac{360N}{370}\right)\right] \tag{18}$$

$$B = 0.175[1 - 0.2\ \cos(0.93N)] - 0.045[1 - \cos(1.95N)] \tag{19}$$

A = apparent solar irradiation at air mass equal to zero, Btu/(hr-ft2) or (W/m2) [7].

B = atmospheric extinction coefficient [7].

On a surface of arbitrary orientation, the direct radiation, corrected for clearness, is:

$$IB_{\beta} = Ib\ max\left(\cos\theta_{\beta}, 0\right) \tag{20}$$

$$IB_{H} = Ib\ max(\cos\theta_{H}, 0) \tag{21}$$

$$IB_{V} = Ib\ max(\cos\theta_{V}, 0) \tag{22}$$

- **Diffuse radiation**

To evaluate the rate at which diffuse radiation Id strikes a non vertical surface on a clear day, the following approximation can be made, (isotropic sky).

* Device uses to measure the diffuse solar radiation power on surface

$$Id = C\ \ Ib\ \ \left(\frac{1+\cos\beta}{2}\right) \tag{23}$$

Energy reflected from ground and surroundings is approximated (diffuse reflection)

$$Ir = \ I_{tH}\ \ \rho_{g}\ \left(\frac{1-\cos\beta}{2}\right) \tag{24}$$

Ir = rate at which energy is reflected on to wall, Btu/(hr-ft2) or (W/m2)
I_{tH} = rate at which the total radiation (direct plus diffuse) strikes the horizontal surface or ground in front of the wall, Btu/(hr-ft2) or (W/m2)
ρ_{g} = reflectance of ground or horizontal surface is given 0.2 for dry bare ground or agricultural [8].

Diffuse solar radiation incident on a non vertical surface,

$$IF = Id + \mathrm{Ir} \tag{25}$$

$$IF_{\beta} = \left[C\ \ \left(\frac{1+\cos\beta}{2}\right) + \rho_{g}\ \left(\frac{1-\cos\beta}{2}\right)(\sin\alpha_{S} + C)\right]\ Ib \tag{26}$$

Where C diffuse radiation factor can be calculated in eq. (26) [7].

$$C = 0.0965\left[1 - 0.42\cos\left(\frac{360N}{370}\right)\right] - 0.0075[1 - \cos(1.95N)] \quad (27)$$

For a horizontal surface,

$$IF_H = \left[C \ \left(\frac{1+\cos\beta}{2}\right)\right] Ib \quad (28)$$

For a vertical surface,

If $\cos\theta_V \geq -2$

$$\frac{I_{dV}}{I_{dH}} = 0.55\ 0.437\ cos\,\theta_V + 0.313\ (cos\,\theta_V)^2 \quad (29)$$

Otherwise

If $\cos\theta_V \leq -2$

$$\frac{I_{dV}}{I_{dH}} = 0.45 \quad (30)$$

$$Id_V = C\ Ib\ \frac{I_{dV}}{I_{dH}} \quad (31)$$

$$IF_V = \left[C\ \frac{I_{dV}}{I_{dH}} + \rho_g\ \left(\frac{1-\cos\beta}{2}\right)(\sin\beta + C)\right] Ib \quad (32)$$

- **Global Solar Radiation**

Total solar radiation incident on a non vertical surface,

$$IG_t = IB + Id + Ir \quad (33)$$

$$IG_{t,\beta} = \left[max(\cos\theta_V, 0) + C\ \left(\frac{1+\cos\beta}{2}\right) + \rho_g\ \left(\frac{1-\cos\beta}{2}\right)(\sin\alpha_S + C)\right] Ib \quad (34)$$

For a horizontal surface

$$IG_{t,H} = \left[max(\cos\theta_H, 0) + C\ \left(\frac{1+\cos\beta}{2}\right)\right] Ib \quad (35)$$

For a vertical surface,

$$IG_{t,V} = \left[max(\cos\theta_V, 0) + C \ \frac{I_{dV}}{I_{dH}} + \rho_g \left(\frac{1-\cos\beta}{2}\right)(\sin\alpha_S + C)\right] Ib \qquad (36)$$

3. RESULTS AND DISCUSSION

This paper presents the simulation results obtained from the above mentioned formulae for calculation of the monthly average of the hourly direct solar, diffuse and global radiation incident on tilted, horizontal, and vertical surfaces in Tripoli city as hourly values. They have been calculated the amount of the monthly average of the hourly direct solar, diffuse and global radiation incident on tilted, horizontal, and vertical surfaces through the entire year for four independent months, which represent each of them the four seasons January, April, July and October of the year of Tripoli city, and also they have been calculated the amount of the direct solar radiation on tilted surfaces as function of sloped angle (β) during the daylight hours for every month, by using Fortran90 for carrying out the analysis.

The results depended on some assumptions that were adopted on the basis of clear days and dust, dirt, trees, and shading effects had been negligible. Calculation of the monthly average of the hourly direct solar, diffuse and global radiation incident on tilted, horizontal, and vertical surfaces was according to the geographic coordinates to Tripoli city which is located at Latitude angle (ϕ) 32.9^o ,longitude angle (L) 13.8^o, height above sea level (h) 81m.

There are several commonly occurring cases for which Equation (10) is simplified. For fixed surfaces sloped toward the south or north, that is, with a surface azimuth angle γ of 0◦ or 180◦ (a very common situation for fixed flat-plate collectors).In this present study the studied surfaces are tilted (β) $0^o, 35^o$, 90^o from the horizontal and pointed (γ) 0^o south. Also have selected day-time hours started from the sixth in the morning to the seventh in the evening.

Figure (3) depicts the relation between the monthly average of the hourly direct solar radiation (ID) incident on tilted, horizontal, and vertical surfaces in Tripoli city against the local time for several different surfaces tilted, horizontal and vertical sloped toward the south for January month which represents wintertime.

It can be observed that higher values of direct solar radiation are on tilted surface, especially at midday-time. Unlike values the direct solar radiation on

horizontal and vertical surfaces. Because of the tilted surface receives the amount of solar radiation due to the effect of solar altitude angle (αs) and solar azimuth angle (γs).

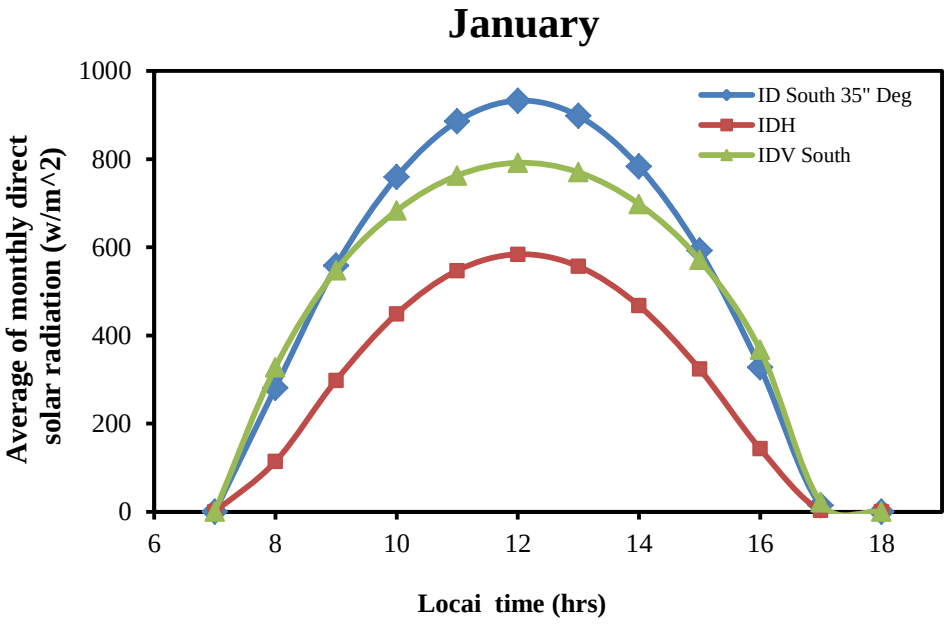


Figure (3) calculation of the monthly average of the hourly direct solar radiation incident on tilted, horizontal and vertical surfaces in Tripoli city

On the other hand, it can be noted that values of the hourly direct solar radiation are lower in the first hours of day-time (zero during sunrise) due to the location difference of the sun towards the earth's surface. i.e., the influence of the angle of the incidence (θ), therefore it can be said that magnitude of the incoming rays from the sun is greater at midday-time about 12 A.M for all the surfaces. The rays which pass through the upper atmosphere layers cross it at a shorter distance in the noontide, and contrarily the distance is longer during sunrise and sunset hours. So the sun's rays are exposing the absorption and dispersion by the atmosphere components. Where can be watched that the direct solar radiation incident on the vertical surface is higher than the direct solar radiation incident on a horizontal surface and these values agree exactly with the reference [3].

Variation of the hourly direct solar radiation incident, ID (the monthly average) on tilted, horizontal, and vertical surfaces against the local time of

Tripoli city for the month of April which represents springtime is shown in Figure (4), where it can be noted that values of the direct solar radiation incident on vertical surface significantly reduced about by 50% from January to April and rose of the horizontal surface about by 50% from January to April. While that values remaining nearly constant on tilted surfaces. The reason is due to reducing Extraterrestrial solar radiation. Furthermore, change the declination angle (δ) from a positive value to a mining value which leads to an increase in the incidence angle (θ). Also, it can be noticed that values of the direct solar radiation incident on two surfaces tilted and horizontal are convergent.

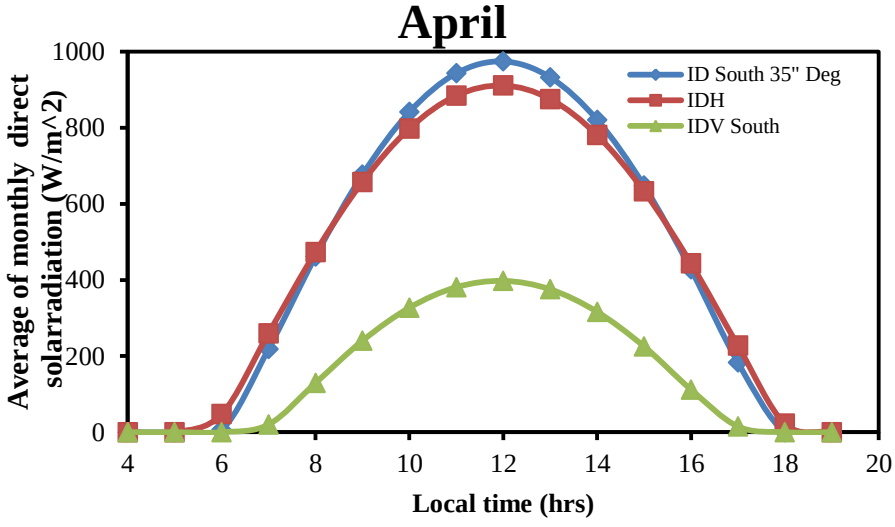


Figure (4) calculation of the monthly average of the hourly direct solar radiation incident on tilted, horizontal and vertical surfaces on April in Tripoli city

In figure (5) presents the variation of the hourly direct solar radiation over Tripoli city on local time starting from the sixth in the morning to the seventh in the evening with several various surfaces tilted, horizontal and vertical pointed (γ) 0o south for month July that represents summertime. Where the hourly direct solar radiation almost linearly increases in the first hours of day-time, especially, tilted and horizontal surfaces are more, until it reaches a maximum at noon time then it decreases gradually.

The hourly direct solar radiation turns at a certain value of noontide, this means that the effect of solar altitude angle (αs), solar azimuth angle (γs), and

variation of the declination angle (δ) from 23.45^{o} to -23.45o results in the decreasing of the incidence angle (θ).

It can be observed that relatively reduction in the solar radiation of the vertical surface, this result in changing the Zenith angle (θz) according to the sequence of day in the year. Where a remarkable change is noticed with regard to the Zenith angle (θz) values in the summer season are about from 65o in the morning to 15o in the noontide. I.e., in July, before 12 noon, the sun moves from the northern half to the southern half of the sky which means that the south vertical surfaces will receive less direct solar radiation, especially in the first hours and the last of the daytime almost is nonexistent. This is comparable almost until for tilted surfaces according to inclined angles. The solar radiation on the inclined and vertical surfaces during this period (the first hours and the last of the daytime) consists of diffuse solar radiation and reflected solar radiation only. This shows the importance of having a good model for these components.

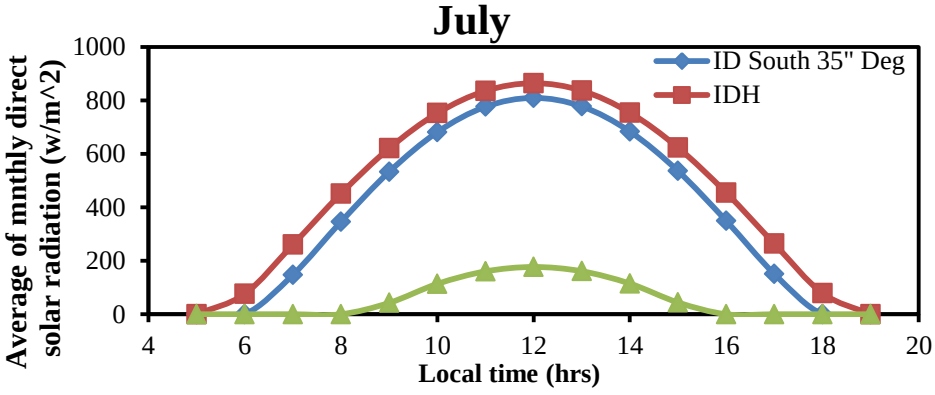


Figure (5) calculation of the monthly average of the hourly direct solar radiation incident on tilted, horizontal and vertical surfaces on July in Tripoli city

Figure (6) illustrates the amount of monthly average of the hourly direct solar radiation incident on tilted, horizontal, and vertical surfaces in Tripoli city for the month of October which represents autumn time. It is evident that the hourly direct solar radiation value of the tilted surface almost is constant relative to all year seasons except summer is less relatively. Moreover, it can be said that the hourly direct solar radiation values of the tilted surfaces for four seasons have recorded higher values and should be taken into account the values during design relative to all solar systems. Also can be noticed that

values of the hourly direct solar radiation incident on two surfaces horizontal and vertical are very convergent relatively.

Figure (7) shows the monthly average of the hourly diffuse solar radiation (IF) incident on tilted, horizontal, and vertical surfaces in Tripoli city against the local time for several different surfaces tilted, horizontal and vertical sloped toward the south for January month which represents wintertime. Where, have selected day-time hours started from the seventh in the morning to the fifth in the evening .It can be noticed a reduction in the hourly diffuse solar radiation rate of the horizontal surface, in the same time convergence values of the diffuse solar radiation incident on tilted and vertical surfaces. Further, the values parities of the hourly diffuse solar radiation of the horizontal surface along day-time period. However, an increase and decrease of solar radiation betweenwhiles determine the extent of energy economy and consumption.

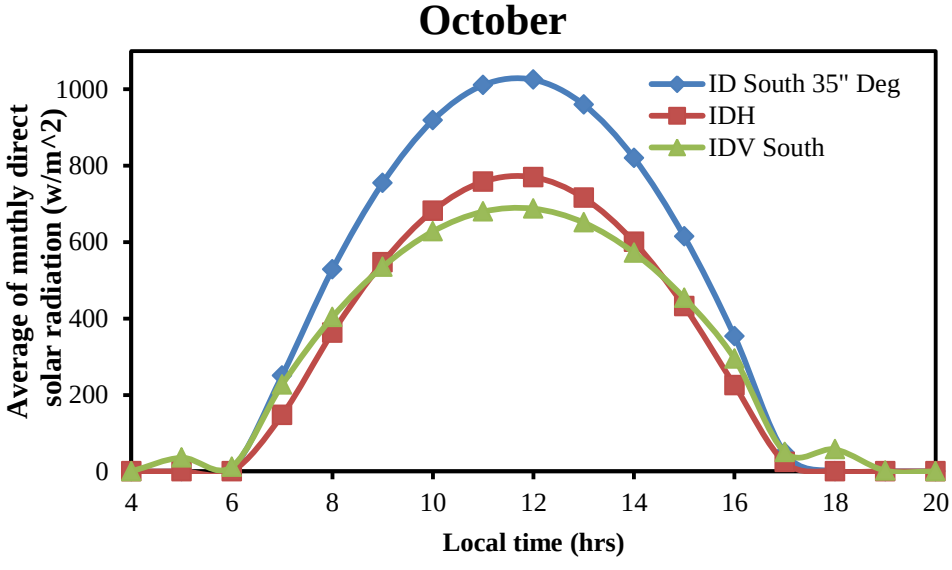


Figure (6) calculation of the monthly average of the hourly direct solar radiation incident on tilted, horizontal and vertical surfaces on October in Tripoli city

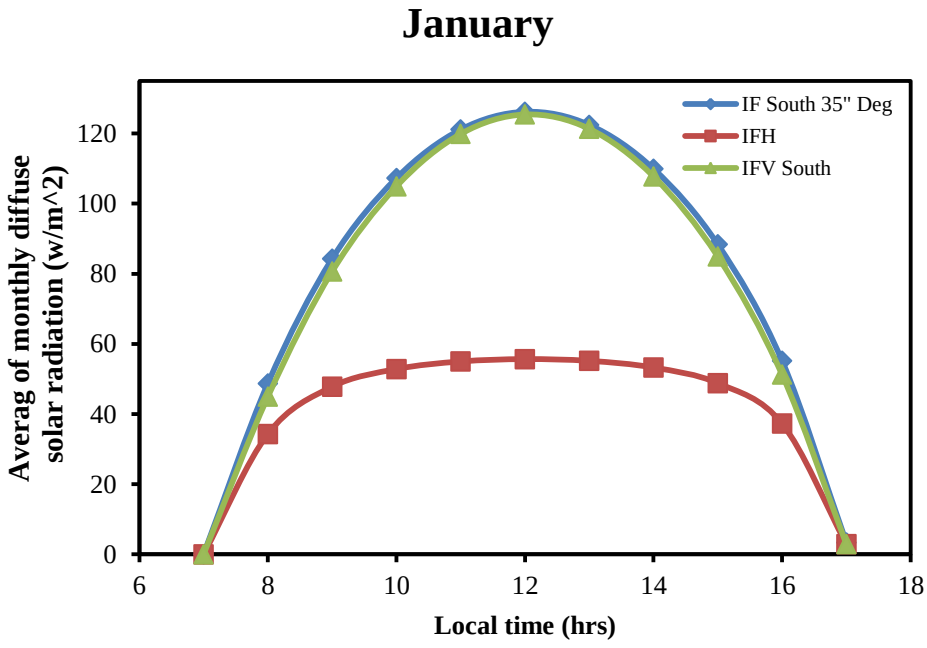


Figure (7) calculation of the monthly average of the hourly diffuse solar radiation incident on tilted, horizontal and vertical surfaces on January in Tripoli city

Calculation of the monthly average of the hourly diffuse solar radiation incident on tilted, horizontal, and vertical surfaces in Tripoli city versus the local time for several various surfaces tilted, horizontal, and vertical pointed (γ) 0^o south for month April which represents springtime is shown in Figure (8). It can be seen evidently that the hourly diffuse solar radiation incident on tilted, vertical, and horizontal surfaces are increasing according to the series of days in the year then decreasing after midyear, furthermore, the values parities of the hourly diffuse solar radiation of the horizontal surface along daylight hours. This indicates that the diffuse solar radiation has a certain value, unlike the beam solar radiation can't have value during the daytime because of the effect of directions and variation of the solar angles, that is, the position of the sun relative to that plane can be described in terms of several angles.

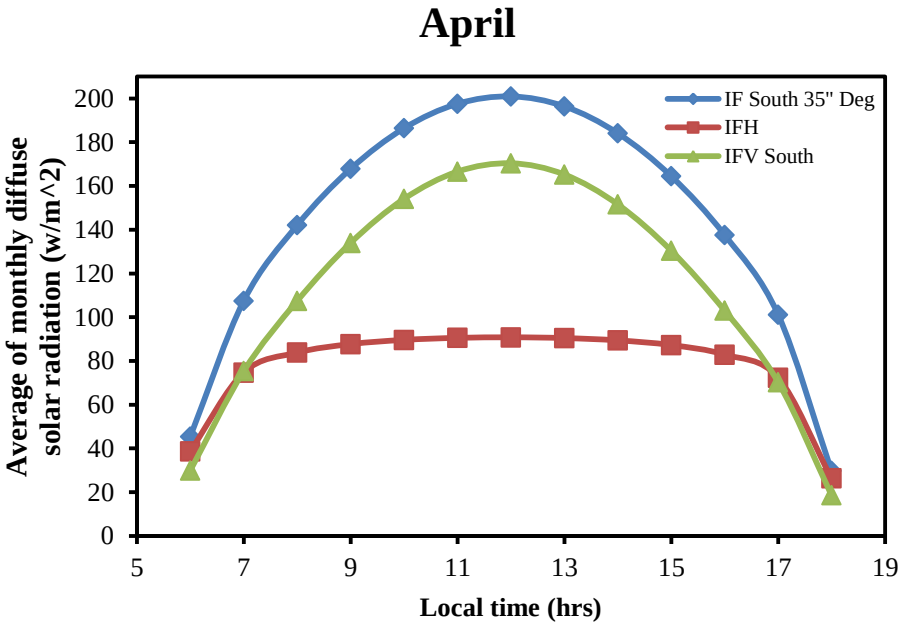


Figure (8) calculation of the monthly average of the hourly diffuse solar radiation incident on tilted, horizontal and vertical surfaces on April in Tripoli city

Figure (9) presents the relation between of the monthly average of the hourly diffuse solar radiation in Tripoli city against the local time for several various surfaces tilted, horizontal, and vertical sloped toward the south (γ) 0o for July month that represents summertime.. Here it is observed that the maximum value of the diffuse solar radiation at midday. I.e. the solar radiation increases until it reaches a maximum at noon time then it decreases. Where it can be said that the tilted surfaces play a significant role in receiving the bundle of the rays with high values when compared with its Successors of the horizontal and vertical surfaces in receiving the rays. It is also noted that the amount or values of the diffuse solar radiation during sunrise and sunset hours are bigger relative to sunrise and sunset hours of the direct solar radiation, that is, for all seasons. Therefore should be taken into considering account diffuse radiation, to get peak value which gives the global solar radiation.

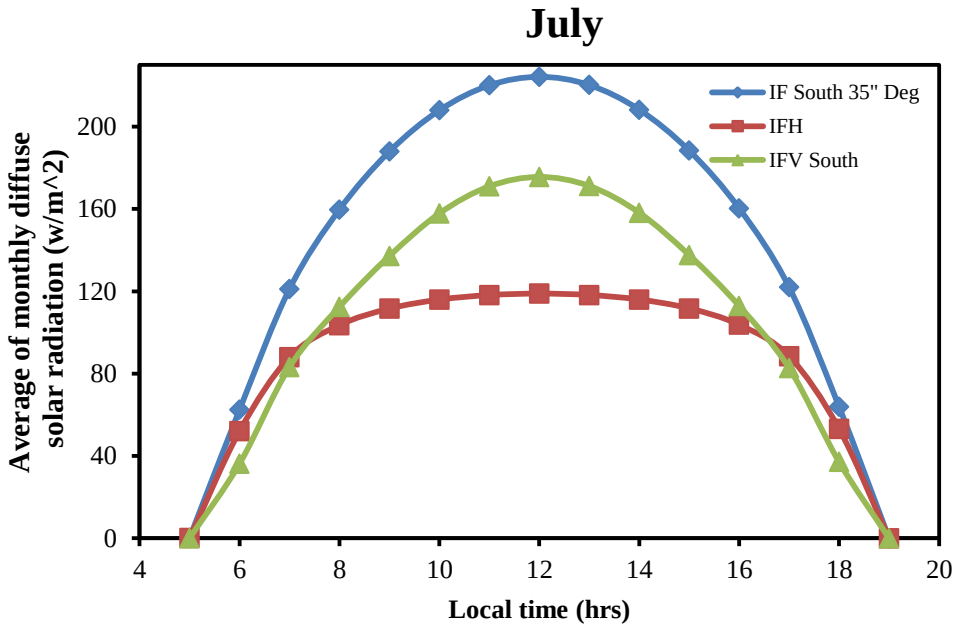


Figure (9) calculation of the monthly average of the hourly diffuse solar radiation incident on tilted, horizontal and vertical surfaces on July in Tripoli city

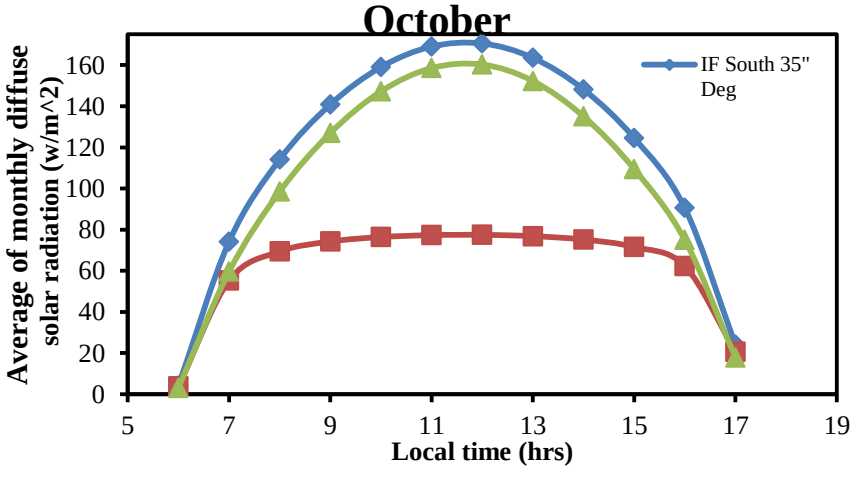


Figure (10) calculation of the monthly average of the hourly diffuse solar radiation incident on tilted, horizontal and vertical surfaces on October in Tripoli city

Figure (10) shows the monthly average of the hourly diffuse solar radiation (IF) incident on tilted, horizontal, and vertical surfaces in Tripoli city against the local time for several different surfaces tilted, horizontal and vertical sloped toward the south (γ) 0o for month October which represents autumn time. Where one can see decreasing radiation intensity, these results confirm the strengths and weaknesses of our yearly calculation very clearly.

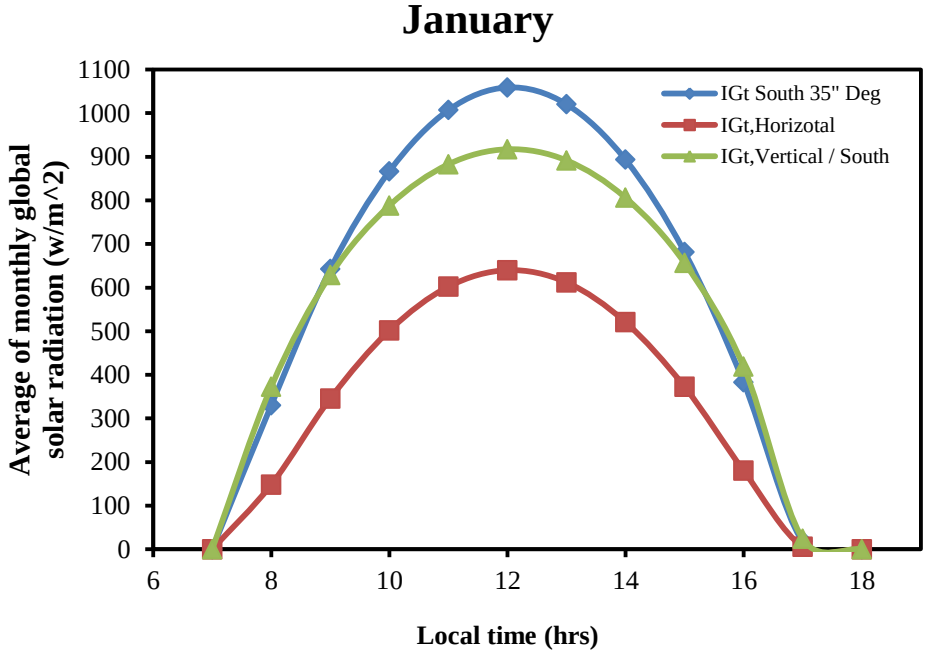


Figure (11) calculation of the monthly average of the hourly global solar radiation incident on tilted, horizontal and vertical surfaces on January in Tripoli city

Global solar radiation incident on tilted, horizontal and vertical surfaces consists of ground reflected, diffuse, and direct radiation .certainly; here we know that global solar radiation received by an inclined, horizontal and vertical surfaces is summation for these rays. Figures (11), (12), (13) and (14), respectively ,present the monthly average of the hourly global solar radiation incident on tilted, horizontal and vertical surfaces in Tripoli city for month January, April, July and October that represent the four reasons, viz, the whole year. Global solar radiation was calculated, maximum values for month January for a cloudless sky were over 1058 W/m^2, 639 W/m^2 and 917

W/m^2 for tilted, horizontal and vertical surfaces, respectively, month April were over 1175W/m^2, 1000 W/m^2 and 568W/m^2 for tilted, horizontal and vertical surfaces, respectively, month July were over 1033W/m^2, 982W/m^2 and 352 W/m^2 for tilted, horizontal and vertical surfaces, respectively, and month October were over 1195 W/m^2, 847 W/m^2 and 847 W/m^2 for tilted, horizontal and vertical surfaces, respectively. These values completely agree with the results shown in reference [3] for two surfaces horizontal and vertical sloped towards south (γ) 0^o.

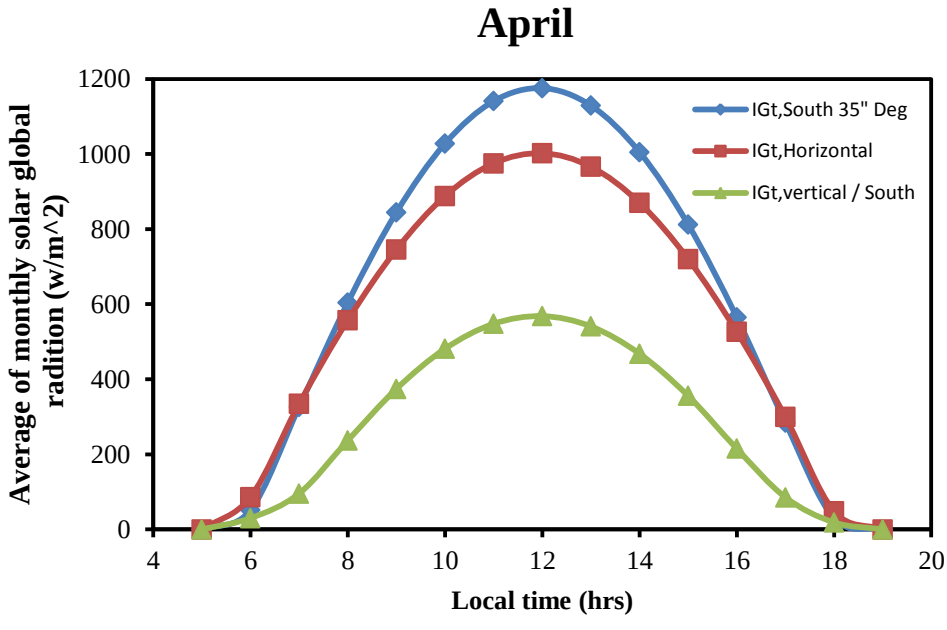


Figure (12) calculation of the monthly average of the hourly global solar radiation incident on tilted, horizontal and vertical surfaces on April in Tripoli city

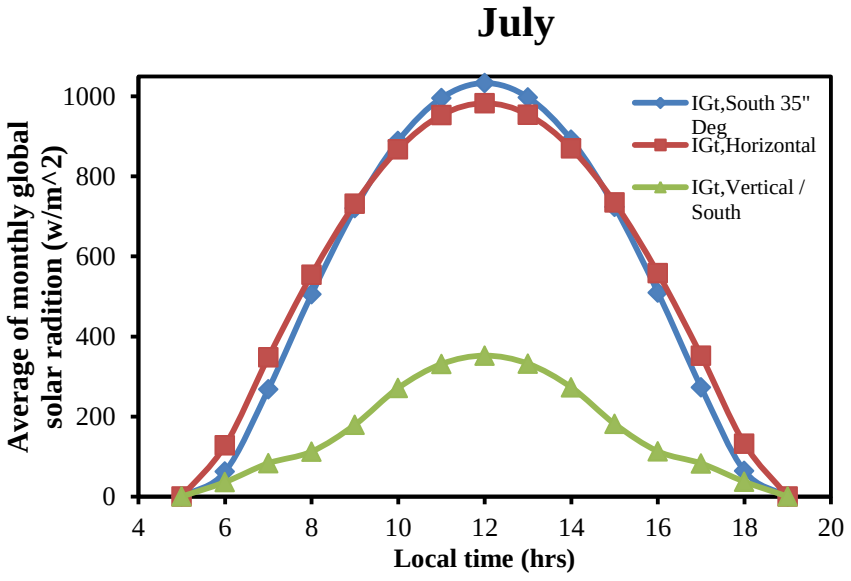


Figure (13) calculation of the monthly average of the hourly global solar radiation incident on tilted, horizontal and vertical surfaces on July in Tripoli city

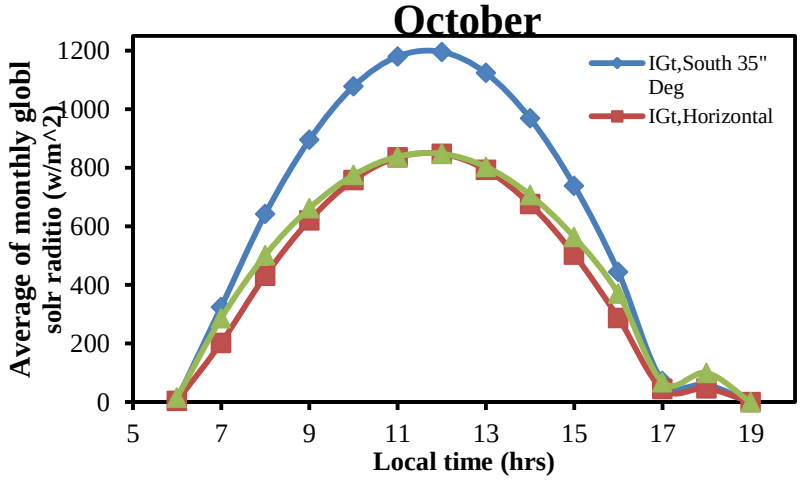
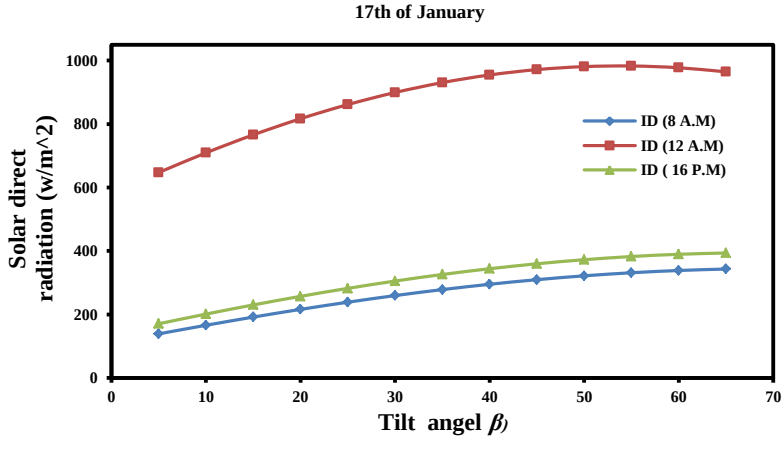


Figure (14) calculation of the monthly average of the hourly global solar radiation incident on tilted, horizontal and vertical surfaces on October in Tripoli city

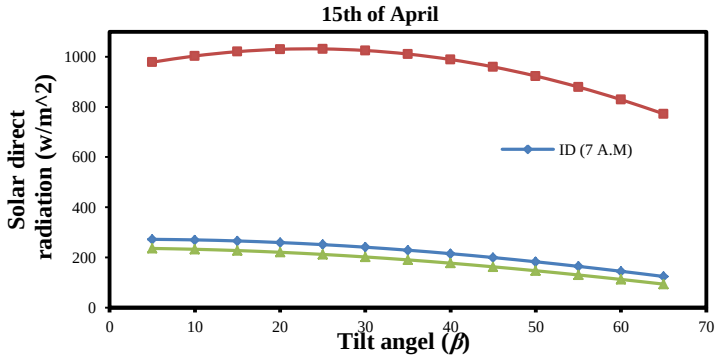
The value of ground reflected radiation increases with the increase of the inclination angle (β). For this reason, the lowest value of ground reflected radiation is 0˚ angle and the highest 90˚ angle for the whole year. The value of diffuse radiation always decreases with the increase of inclination angle (β) owing to the value of scattered and reflected radiation on tilted surface decreases. That is why; the highest value of diffuse radiation is 0˚ angle and the lowest 90˚ inclination angle, for all months of the year. In this present study, the value of beam radiation relies upon various inclination angles and the highest value of beam radiation is found on the optimal tilt surface. Figure 21 shows the variation of beam radiation for various inclination angles (β).

One can notice that optimal tilt angle refers to such an angle for which the value of solar radiation on that surface becomes the highest. In January, almost the optimal tilt angle is 55˚. In April, the optimal tilt angle is 10˚.In July, the optimal tilt angle is 0˚. In October, the optimal tilt angle is 45˚.

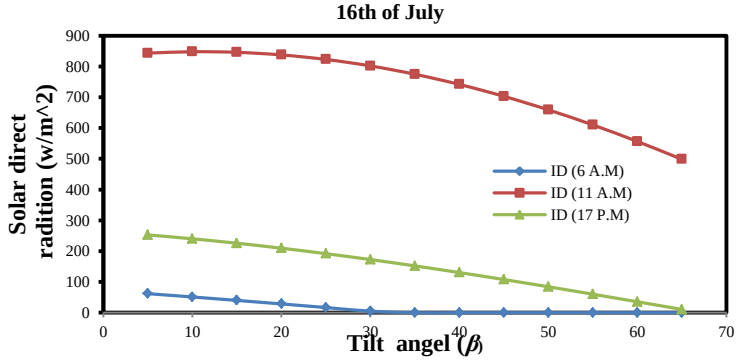
The optimal tilt angle mainly depends on Sun's declination and latitude. In this study, when the sun's declination increases from December solstice to June solstice, then the value of optimal tilt angle decreases. This is evident in Figure 15 for the month of January, the optimal tilt angle is 55˚, in April; the optimal tilt angle is 10˚ then for month July, is 0˚. After the June solstice the declination decreases and the value of the optimal tilt angle increases. Where is increasing from 0˚ in July to 45˚ for month October.



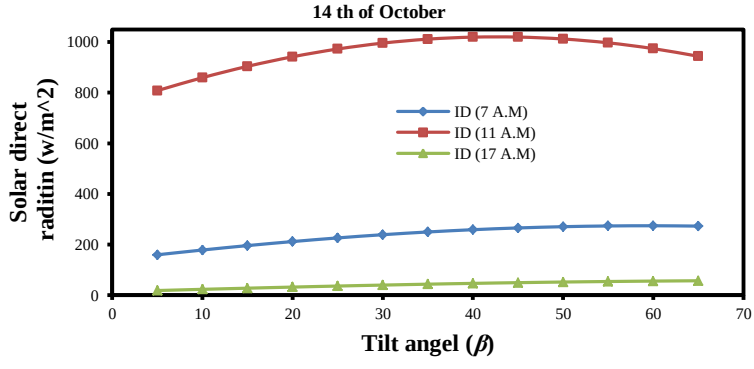
(a)



(b)



(c)



(d)

Figure (15) Variation of beam solar radiation for various inclination angles for month January (a), April (b), July (c) and October (d).

4. CONCLUSIONS

In this present study, the simulation results have been obtained by a developed computational model using Fortran90, which gives the prediction of hourly terrestrial solar radiation incident on tilted, horizontal, and vertical surfaces: direct beam, diffuse and global. Where, the same parameters were modeled for inclined, horizontal, and vertical surfaces. Thus, an important tool for building and solar thermal systems design, simulations, and performance assessments has been developed. The predicted hourly solar radiation incident was compared for tilted, horizontal, and vertical surfaces with each other locally in Tripoli city.

The effect of tilt angle and orientation on the incident solar radiation fluxes are presented along with optimum surface tilt angles and directions for maximum solar radiation collection in the area. This information is useful when a simple solar collector is to be installed without a tracking system. In general, surfaces tilted toward the East and the West have similar trends and the trend is almost the same for other tilt angles. Here, for the surface tilted towards the South, in the period April and October, the effect of tilt angle on the received global solar radiation is positive. However, the tilt angle has a more significant effect in April and October and relatively less in January and July. The results of this study were summarized more below:

1- In general, the research work reported in this paper will help in increasing the level of knowledge relating to solar radiation on horizontal and tilted vertical surfaces and estimate the solar energy potential for practical and efficient utilization in Tripoli city.
2- The effect of the solar radiation incident on tilted is the largest with regard to the solar radiation incident on horizontal and vertical surfaces, therefore advised to utilize tilted surfaces.
3- The total solar radiation increases for two surfaces horizontal and inclined whenever moved us with time from winter, spring, summer then autumn season. Unlike that the total solar radiation decreases for vertical surface as result of decreasing or increasing of solar angles.
4- The highest value of total solar radiation is recorded for inclined surface in October.
5- Diffuse solar radiation plays vital role in increasing energy during day-times especially in the morning the first hours and in the evening the last

hours of daytime, also is available relative to another directions North, South, West and East. Unlike the direct solar radiation.

6- For horizontal surfaces, compared with April, the direct solar radiation during month January, July and October are lower. The maximum direct radiation is reached at a tilt angle of 0o is 911 W/m2 for month April.
7- The results presented in this paper are quite useful for quick estimation of solar radiation for calculations of cooling load and solar collectors' performance.

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