Design gas compression station of Nasiriya oil felid

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Abstract— **centrifugal compressors, also called radial compressors, are critical equipment in a wide variety of applications in chemical process industries .their primary purpose is to compress a fluid (a gas or gas/liquid mixture) into a smaller volume while simultaneously increasing the pressure and temperature of the fluid a comparison was made between the centrifugal and reciprocating compressor in terms of power requirement, flow rate, and discharge pressure, and choosing the best for Nasiriya oil field.**
After analyzing the results, it was found that the centrifugal compressor is better than the reciprocating compressor by obtaining a higher discharge pressure and a higher flow.

I. NTRODUCTION

Gas Compressor Compressors are used for providing gas pressure required to transport gas with pipelines and to lift oil in gas - lift operations. The compressors used in today's natural gas production industry fall into two distinct types: reciprocating and rotary compressors. Reciprocating compressors are most commonly used in the natural gas industry. They are built for practically all pressures and volumetric capacities.

Reciprocating compressors have more moving parts and, therefore, lower mechanical efficiencies than rotary compressors. Each cylinder assembly of a reciprocating compressor consists of a piston, cylinder, cylinder heads, suction and discharge valves, and other parts necessary to convert rotary motion to reciprocation motion. A reciprocating compressor is designed for a certain range of compression ratios through the selection of proper piston displacement and clearance volume within the cylinder. This clearance volume can be either fixed or variable, depending on the extent of the operation range and the percent of load variation desired. A typical reciprocating compressor can deliver a volumetric gas flow rate up to 30,000 cubic feet per minute (cfm) at a discharge pressure up to 10,000 psig . Rotary compressors are divided into two classes: the centrifugal compressor and the rotary blower.

Centrifugal compressor consists of a housing with flow passages, a rotating shaft on which the impeller is mounted, bearings, and seals to prevent gas from escaping along the shaft. Centrifugal compressors have few moving parts because only the impeller and shaft rotate. Thus, its efficiency is high and lubrication oil consumption and maintenance costs are low. Cooling water is normally unnecessary because of lower compression ratio and less friction loss. Compression rates of centrifugal compressors are lower because of the absence of positive displacement. Centrifugal compressors compress gas using centrifugal force. In this type of compressor, work is done on the gas by an impeller. Gas is then discharged at a high velocity into a diffuser where the velocity is reduced and its kinetic energy is converted to static pressure. Unlike reciprocating compressors, all this is done without confinement and physical squeezing. Centrifugal compressors with relatively unrestricted passages and continuous flow are inherently high capacity, low - pressure ratio machines that adapt easily to series arrangements within a station. In this way, each compressor is required to develop only part of the station compression ratio. Typically, the volume is more than 100,000 cfm and discharge pressure is up to 100 psig [1]

II. THE AIM OF THE PROJECT

Design suitable compressor for operational conditions in Nasiriya oil field and hence we get the following:

1. Exploiting gas in the Nasiriya field economically.

2 .Elimination of environmental damage resulting from gas flaring in Nasiriya field.

3 .Provide job opportunities through the establishment of new gas compressor stations in the Nasiriya field.

III. STUDY AREA

Nasiriya oil field is located in Thi_Qar Governorate about (38 km) north-west of Nasiriya city .The field lies east of the River Euphrates .The field latitudes is 34 80’ -34 60’ N and longitudes 57 50’ -60 10’ E, which includes twenty-eight (28) wells .Figure 1 show Nassiriya oil field location map.

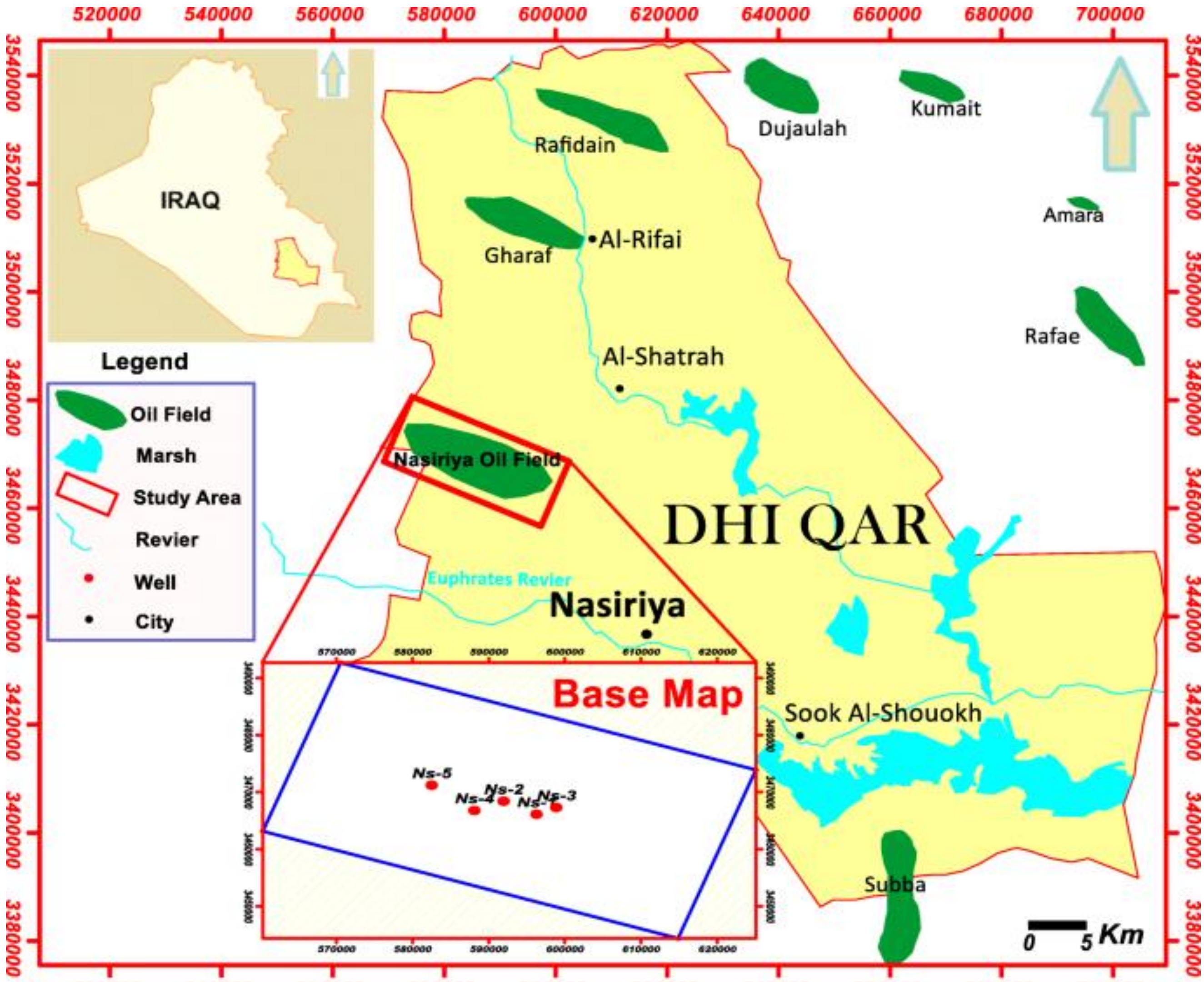

Figure 1. Nassiriya oil field location map[2] .

IV. LITERATURE REVIEW

There are many types of optimization techniques and models related to natural gas systems especially related to natural pipeline network systems in literature. These optimization models and techniques can be applied separately in production and transportation of natural gas and also in the natural gas market. In the literature, there are three main network problems which are used to handle different challenges in NG transmission networks. In NG network design problems, the objective function may be minimization of the investment cost or maximization of the net present value. The output of the model helps to locate the optimal type and the number of compressor stations, and to select the optimal pipe dimensions. Several design variables need to be determined. They include the location and type of compressor stations; possible locations, lengths

and diameter of pipelines to be installed; and the allowable operating pressure levels of the system [3].

NG network problems aim to minimize costs and meet demand. Decision variables of the problem are defined to determine gas through the pipeline network. The operation cost of NG transmission systems is highly dependent on the compressor station operations because the amount of NG in the system is set by compressor stations. In these problems, selecting the optimal compressor location and capacity is a critical decision. In network expansion problems, the objective is generally scheduling the investments to obtain the optimum capacity expansion, investment decisions including time, size and location of pipeline and compressor station installations should be made Many studies have been done in pipeline network optimization including the pipeline network design, the minimization of fuel consumption of compressor stations, economically locating compressor stations in the network [4]. Rios-Mercado et al. (2001) proposed a reduction technique to minimize the fuel consumption of compressor stations in steady-state transmission networks. This method minimizes the problem dimension at preprocessing without disrupting the problem structure [4].

Uraikul et al. (2003) proposed a mixed integer linear programming model (MIP) to optimize the operations of selecting and controlling the compressors. The objective of the study is to minimize the operating costs of the network and meet customer demands in the system. The three factors that affect the costs are the capacities of compressors, the energy used to turn on the compressors, and the energy used to turn them off. The model was tested on a network that has two compressor stations, two customer locations and six periods [5].

Adeyanju and Oyekunle (2013) presented an optimization procedure of natural gas transmission network by using the Reduced Gradient algorithm, which is a mathematical optimization technique. By guiding this optimization technique, they determine the optimum economic conditions for transporting natural gas with pipelines and compressor stations. Finally, they applied the same model to Exclaves Lagos pipeline network system [6].

V. Theory

A. the centrifugal compressor

Is a dynamic machine that achieves compresion by applying inertial forces to the gas (aceleration, deceleration, and turning) by means of rotating impellers The centrifugal compressor is made up of one (single stage) or more stages (multi- stage), each stage consisting of an impeller and a diffuser. Moving parts since only the impeller and shaft rotate. These compressors have low maintenance and oil consumption costs. They normally operate with large capacity with relatively low-pressure ratios. Centrifugal compressors are the second most popular compressors after reciprocating compressors. One aspect of centrifugal compressors is the distinction between stages and sections. In centrifugal compressors, multi-stage compression takes place without cooling and it is largely limited by the polytropic head requirement, as well as the compression ratio. After a multi-stage compression, the gas may be cooled before going to the next "section". To summarize to summarize, multi stage compression in centrifugal compression implies compression without cooling; whereas, multi-section compression implies compression with inter-stage cooling. The principle of centrifugal compression is different than reciprocating compression. Kinetic energy is converted to pressure energy through impeller- diffuser pair centrifugal compressor this type of compressor works by relying on centrifugal force by stirring and stirring the gas as a result of the rotation of propeller thrusters called impellers. Rotation and then the gas enters the vortex chamber at a high speed, and this speed turns into pressure when it passes through the diffuser, meaning the gas pressure will increase against a decrease in its speed. Stage as is the case in the compressor stations, the gas will exit to enter another impeller through the guide blab to raise another amount of gas pressure. For example our compressors consist of two stages of compression, the first consisting of eight impellers and the second of six, and in general, the gas compressor is composed of casing - impellers axis, and the most important part of it is the impeller. The higher the pressure, the higher the pressure, we have to use a compressor with a larger number of impellers. Figur 2 show The centrifugal compressor parts[7].

B .Reciprocating compressors

Are the best known and most widely used compressors of the positive displacement type. They operate on the same principle as the old, familiar bicycle pump, that is, by means of a piston in a cylinder. As the piston moves forward in the cylinder, it compresses the air or gas into a smaller space, thus raising its pressure. The basic reciprocating compression element is a single cylinder com pressing on one side of the piston (single-acting). A unit compressing on both sides of the piston (double-acting) consists of two basic single-acting elements operating in parallel in one casting. Most of the compressors in use are of the double-acting type. Figure2 shows a cross section of another variant—a V-oriented, two-stage, double-acting water-cooled compressor [8] .

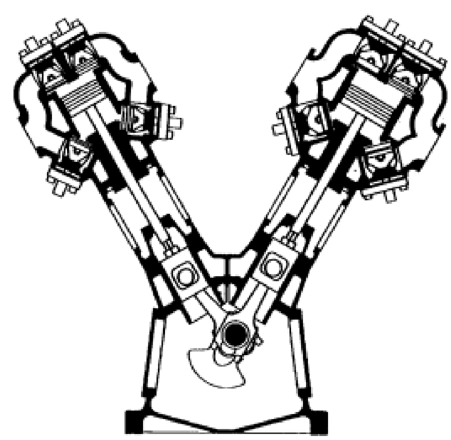

Figure2Multistage, double-acting reciprocating compressor in V-arrangement [8] .

VI. Methodology

This study based on field data for the Nasiriya oil field. Based on this information, a comparison was made between the centrifugal compressor and the reciprocating compressor, and the selection of the economically best compressor.
The methodology was using in this study as following:

A. Centrifugal Compressor Calculations

1-Calculate polytropic exponent (n) assume apparent polytropic efficiency (ηp) = 0.7

$$\frac{n-1}{n} = \frac{k-1}{k\,\eta p}$$ [9]

(1)

2-Calculate discharge temperature T2 assume single section [9].

$$r = \frac{p2}{p1} \quad (2)$$

$$T2 = T1\, r^{\frac{n-1}{n}} \quad (3)$$

T2 > 475 ºF another section is needed
T2 < 475 ºF only one section is needed.
3-Find Zavg [9].
Tpc = 168 + 325yg- 12.5yg2 (4)
Ppc = 667 + 15yg – 37.5 γg2 (5)

- Find Tpr and Ppr for both suction and discharge conditions.
- Use Standing and Katz chart Figure 3to find Z1, Z2.
- Find Zavg.

$$Zavg= \frac{Z2+Z1}{2}$$

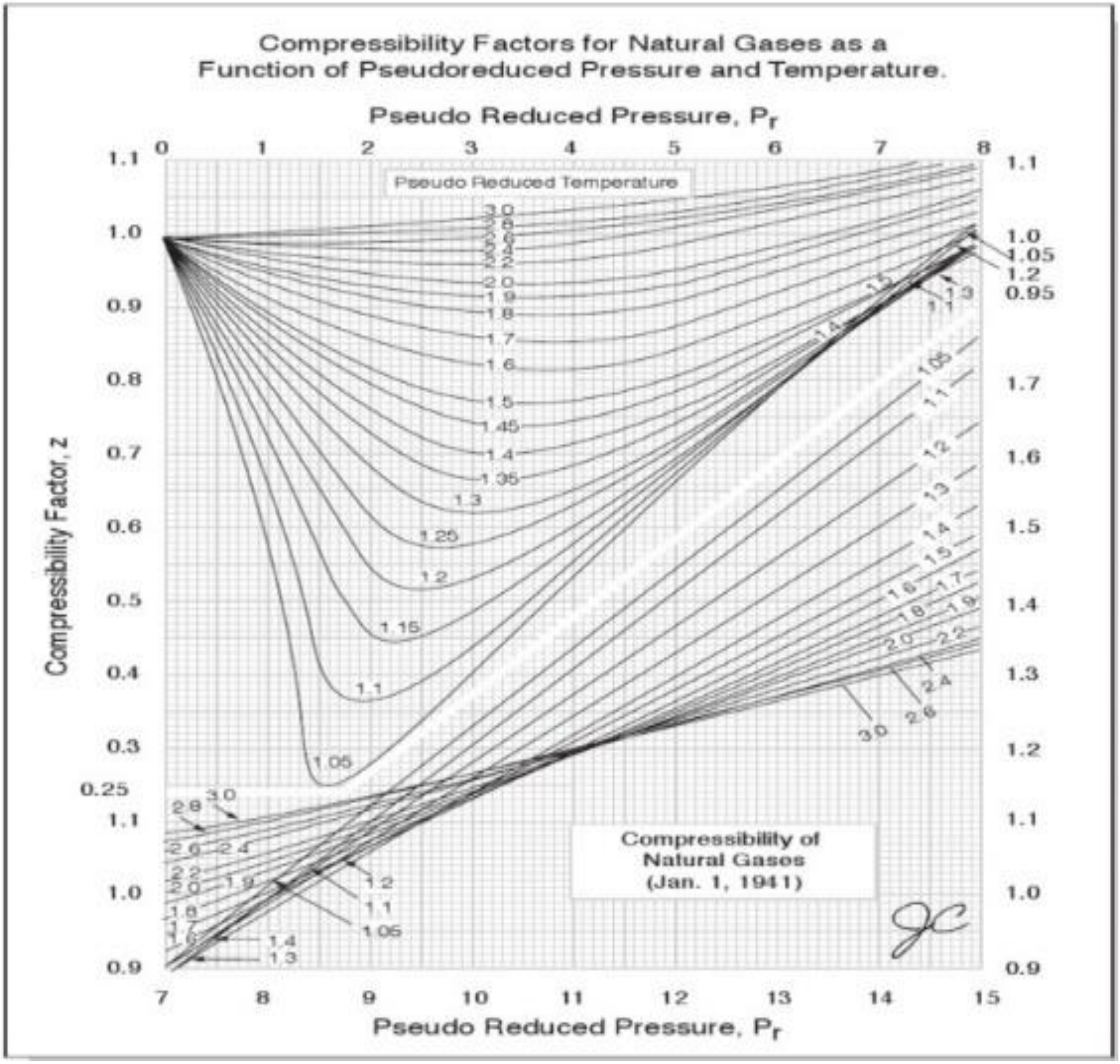

Figure.3Standing and Katz chart [10]

4-Calculate the total polytropic head (Hp) in (ft. lbf /lb) [9].

$$Hp = \frac{53.29}{YG}\, Zaveg.T1.\ \frac{n}{n-1}\left[r^{\frac{(n-1)}{n}} - 1\right] \qquad (7)$$

5-Calculate the allowable polytropic head (Hpa) in (ft. lbf /lb) [9].

$$Hpa = 10000 + 100(29\text{-}29\gamma g) \qquad (8)$$

6-Calculate number of stages (ns)

$$ns = = \frac{\text{Hp}}{\text{Hpa}}$$

If ns > 8 new section is needed.
If ns < 8 only one section is needed.

7-Calculate the head per stage (Hpa / ns)[9]

$$Hpa = \frac{\mathbf{Hp}}{\mathbf{ns}} \qquad (10)$$

8-Calculate the volume at the inlet.

$ACFM = 19.6\,\frac{\boldsymbol{Z1\,T1}}{\boldsymbol{P1}}\,\boldsymbol{qsc}$ (11)

$qs.c.$ = given flowrate in MMSCFD

9-Calculate impeller diameter (di) in (inch). From Figure. 4 find impeller diameter [9].

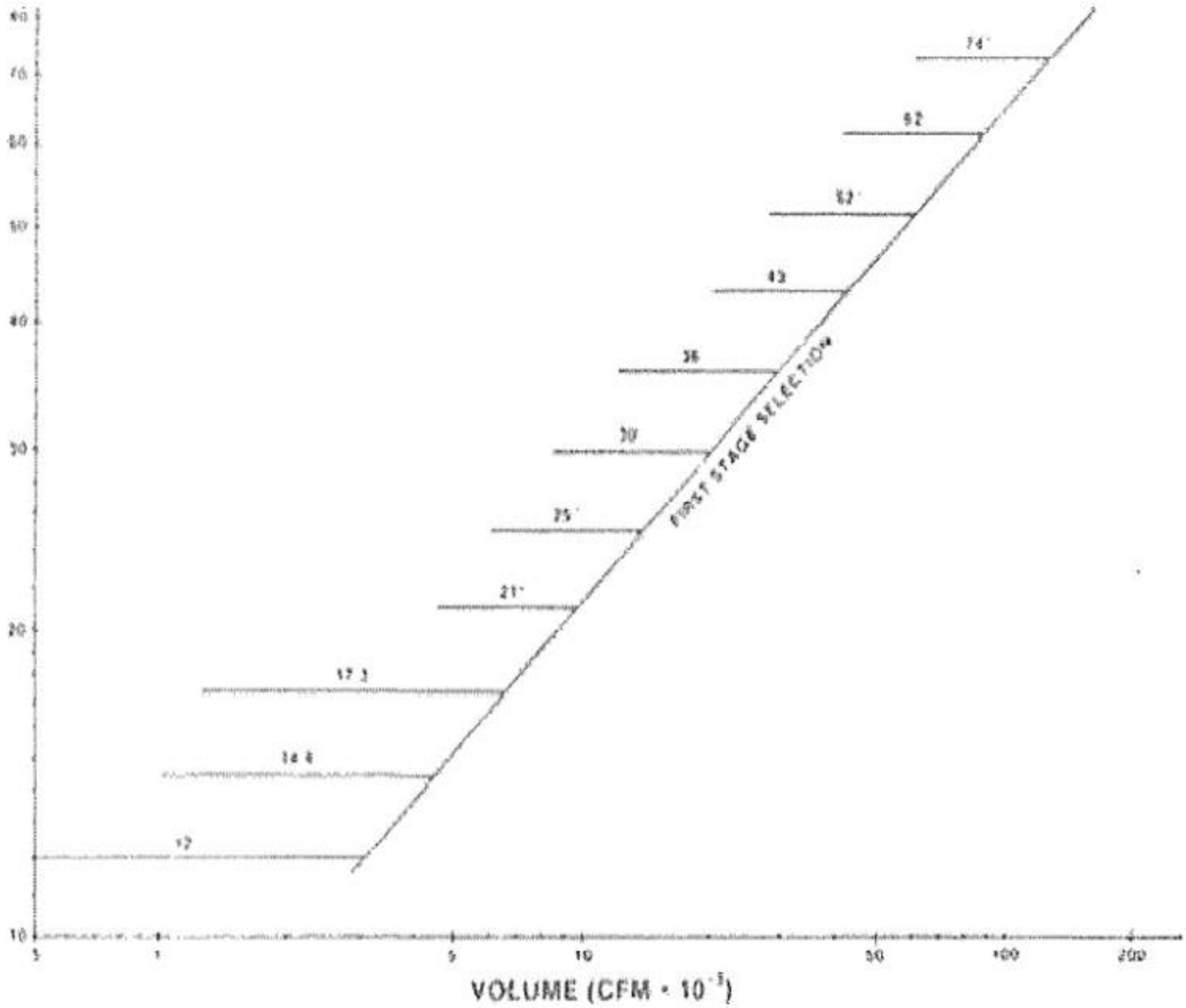

Figure4 Impeller diameter estimation [9]

10-Calculate the impeller speed (U) in (ft/sec.) [9]. π

$U = \left[\frac{\textbf{head per stage}*\mathbf{32.2}}{\mathbf{0.48}}\right]\mathbf{0.5}$ (12)

11-Calculate rotational speed (N) in (rpm).

$N = \frac{\mathbf{U}}{\boldsymbol{\pi}\,\mathbf{di}} * \mathbf{60}$ (13)

12-Calculate Polytropic efficiency [9]

Find the volume flowrate at the last stage in (ACMF).

$$Qlast= \frac{Qin}{\left[r^{1-\frac{1}{ns}}\right]^{\frac{1}{n}}} \quad (14)$$

Where

Qin= inlet rate in ACMF.

- Calculate the inlet flow coefficient

$$\delta = 700 \frac{Q}{N\ di3} \quad (15)$$

Use figure. 5 to calculate the actual polytropic efficiency.

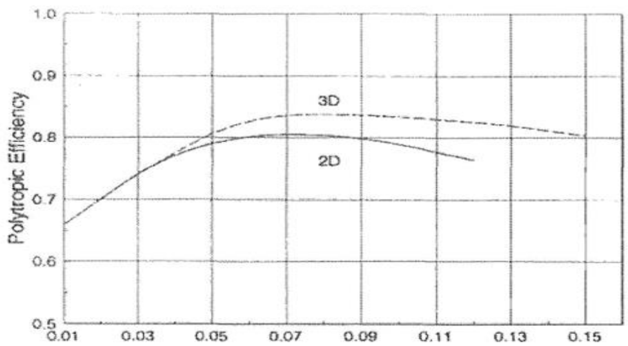

Figure 5. estimate polytropic efficiency [9].

13-Compare between the assumed and actual polytropic efficiencies if there is a large difference between them repeat steps from1 to 12 using the new value of polytropic efficiency.

14- Power requirements

$$HP=0.0857\ Zaveg\ .\left[\frac{qsc\ .T1}{Em.\eta p}\right] \frac{n}{n-1} \left[r^{\frac{(n-1)}{n}} - 1\right] \quad (16)$$

Em = mechanical efficiency if not given assume it 0.99

B .Reciprocating compressors Calculations

1- Power Requirement

$$W = \frac{3.027\ PSC\ T1K}{TSC(K-1)} \left[r^{\frac{z1\ (k-1)}{k}} - 1\right] \ [11] \quad (17)$$

2- Find the Efficiency

$Efficiency$ = (Theoretical horsepower bh)/ ((Brake or actual horsepower)) (2)

Find the Efficiency From Figure. 6

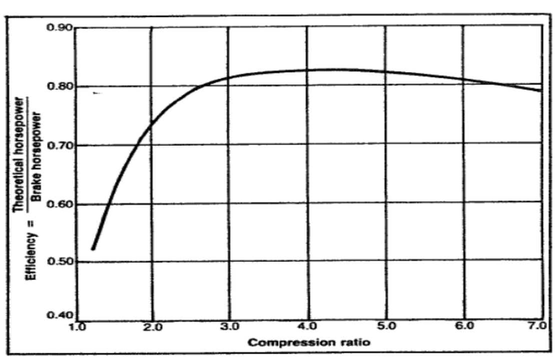

Figure 6 Reciprocating compressor efficiency [11]

VII. Case field study

This includes field information which contains the composition of natural gas of Nasiriya oil field in addition to the natural gas properties. And it made a comparison between the centrifugal and reciprocating compressor by calculating the power requirement and efficiency, as shown below.

A .design data

Compound	1stage	2stage	3stage	4stage
Methane	77.51	52.139	24.194	6.617
Ethane	14.493	28.103	37.876	35.81
Propane	5.275	13.19	26.786	33.13
Isobutene	0.488	1.331	0	5.122
n-butane	1.159	3.126	7.321	11.95
iso pentane	0.242	0.611	1.411	3.044
n-pentane	0.282	0.701	1.611	3.128
Hexanes	0.07	0.181	0.381	0.785
co2	0.469	0.611	0.42	0.223
N2	0.012	0.007	0	0.061
H2S	0	0	0	0.13
TOTAL	100	100	100	100

Table .1 Composition of natural gas by gas chromatography

Fluid density	12.99 kg/m3
molecular weight	20.512
Specific heat ratio(K)	1.325
suction pressure	217.5 Psia
discharge pressure	797.7 psia
suction Temperature	80 ºF
flow rate	23 MMSCFD
Specific gravity of gas	0.7

Table .2 natural gas properties

B. RESULTS

The following parameters are calculated for the centrifugal compressor and reciprocating compressor using Methodology above .results shown in table 1 and table 2.

1-polytropic exponent (n) 2- discharge temperature (T2) 3–ratio pressure (r) 4- the total polytropic head (Hp) 5- the allowable polytropic head (Hpa) 6- number of stages (ns) 7- the volume at the inlet ($ACFM$)8- impeller diameter (di) 9- the impeller speed (U)10- rotational speed (N) 11- the volume flowrate at the last stage in (Qlast)12- the inlet flow coefficient (δ) 13- Power requirements (HP)14- the actual polytropic efficiency(ηp). 15- Theoretical horsepower (Wt) 16- Brake or actual horsepower(W)

Parameter	Value	Units
N	1.539	/
$\boldsymbol{r}$	3.66	/
$\boldsymbol{T2}$	850	$\boldsymbol{R^o}$
Z1	0.94	/
Z2	0.96	/
$Zavg$	0.95	/
Hp	63985	ft.Ibf/Ib
Hpa	10870	ft.Ibf/Ib
ns	5.8 ≅ 6	/
Hpa	10664.166	Hpa / ns
$ACFM$	730*$\boldsymbol{10^3}$	ft3/ min
Di	16	In
U	845	ft/sec
N	12109	$\boldsymbol{rp}$m
$Qlas$	361 *10^3	ft3/ min
δ	0.0108	/
ηp	0.68 ≅ 0.7	/
Hp	2467.06 Hp	Hp

Table. 3 results Centrifugal Compressor

Parameter	Value	units
wt	1357 HP	HP
E=0.72	0.72	/
W	1884 HP	HP

Table. 4 results reciprocating compressor

C. DISCUSSION

The discharge temperature 850 is considered acceptable because it is smaller than 935, and according to Equation 3, we need one section, that is, without cooling. As for the reciprocating compressor, it is considered high and we need cooling between the stages.

The diameter of the impeller 16 is considered a large hole, and that is because it needs more space and high energy.

Efficiency is 68%. This value is considered low for the centrifugal compressor range (75%-85%). Compared to the efficiency of the reciprocating press, which is equal to 72%, it is considered good.

Power requirements depend on flow rate and polytropic efficiency. Figure 7 shows the assumption of different flow rate and the constant of the efficiency at 68%. We note that the power increases with an increase in the flow rate, which leads to an increase in the cost. Figure 8 shows the assumption of different efficiency and constant flow rate at 23MMSCFD. We notice that the power decreases with the increase in efficiency and this leads to the reduction of costs. Figure 9 shows Power requirements with the assumption of different flow rate note that the value of the power required to centrifugal is (2467.06 HP) and the power required for the reciprocating compressor is (1884 HP). And from that we find that the reciprocating compressor is less cost in (fuel consumption in startup) than centrifugal. Figure 10 shows the relationship of inlet pressure with discharge pressure for both compressors. It was found that the centrifugal compressor gives a higher discharge compared to the reciprocating.

After that we studied the Pressures of Nasiriya oil field and found that pressures of this field is low and when we did the calculations we find the inlet and outlet pressures for both compressors and by depending on main line pressure we found that centrifugal is more suitable for this field in terms of pressure and also for the futuristic production increase.

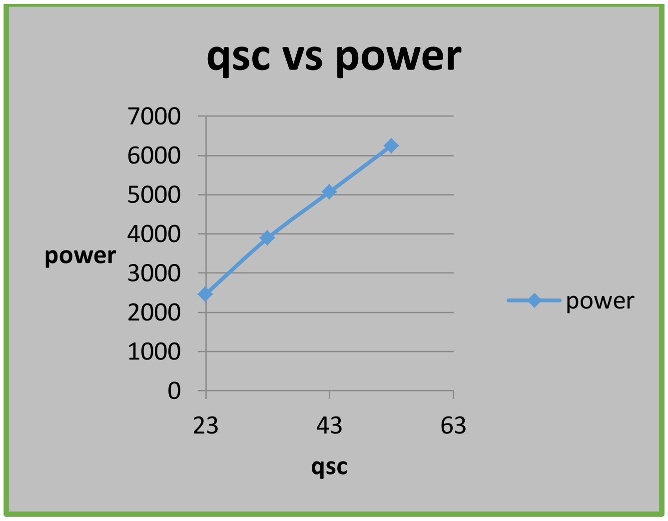

Figure.7 power is function of flowrate

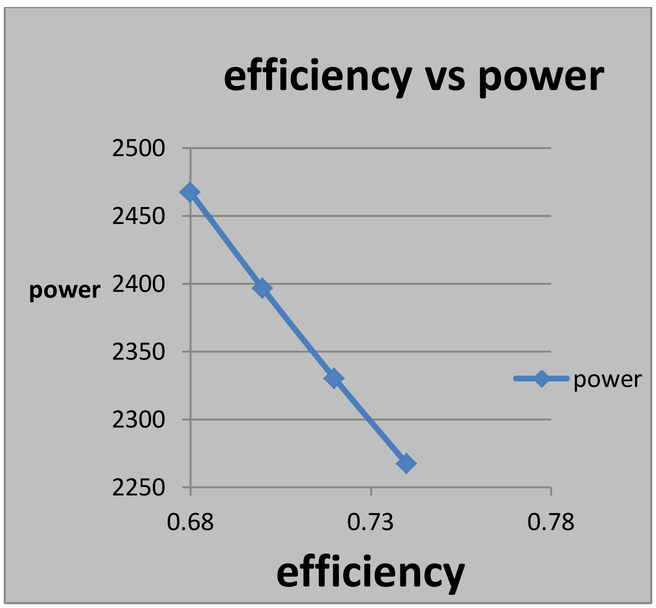

Figure.8 power is function of efficiency

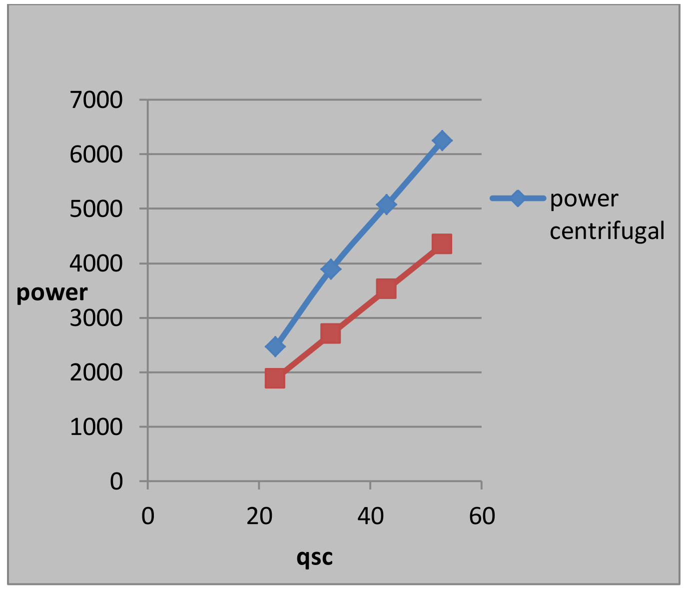

Figure9. power is function of flow rate of type's compressors

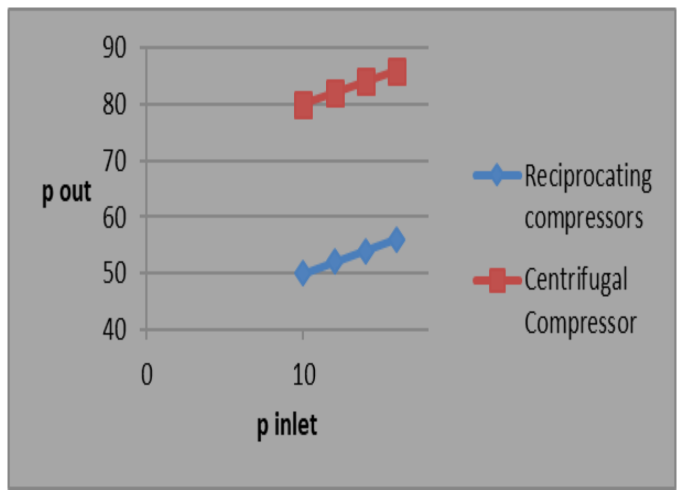

Figure.10 relationship between inlet pressure and out pressure

VIII. Conclusion

At the end of this research, we were able through this research to shed light on all aspects related to the topic of research (Design gas compression station of Nasiriya oil felid) and we put the theoretical and practical aspects of this research by making a comparison between the centrifugal and reciprocating compressor, and at the end of the research we reached the following results

1) Centrifugal low inlet pressure and high discharge pressure.
2) Centrifugal has the highest flow rate compared to other types.
3) Centrifugal is more economic in the long run.
4) The centrifugal compressor is more suitable for the Nasiriya oil field.

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