Journal of Petroleum Research and Studies

Open Access
No. 34 part 2, April 2022, pp. 316-330

P- ISSN: 2220-5381
E- ISSN: 2710-1096

DOI: http://doi.org/10.52716/jprs.v12i1(Suppl.).640

Save Energy in Choosing Oil Pumping Systems

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6th Iraq Oil and Gas Conference, 29-30/11/2021

Abstract

Some non-specialists raised problems about the turbine pumping system in the Al-Faw oil depot, and it reached the Office of Internal Oversight and some deputies in Parliament, so I decided through the research to clarify the basis on which to rely on appropriate pumping systems to achieve the required operational conditions with the least energy expended And this reflected the choice of pumping systems that were chosen to work in Al -Faw oil depot. Through the research, it was found that the best way to choose oil pump systes and to save the energy used for pumping is to use the variable speed of the pump with the use of the parallel pumping system for multi pumps, which was used in the Faw oil depot.

1. Introduction:

A pump transfers mechanical energy to a fluid by raising its pressure. It is a device that moves fluids (liquids or gases) by mechanical action [1].

Pumping systems constitute an essential and influential part in the oil industry, and that the efficiency of their work, the energy required for their work, and the costs that are reflected in this constitute a major issue in the oil industry.

When one pump is used for different flow rates and pressures, the pump design is adopted on the basis of the maximum required pressure and flow rate. Therefore, in many cases, especially at the beginning of pumping, the pump operates outside the performance and efficiency curve, so it is resorted to using the circulation method that part of the The pumping fluid to the intake point or when resorting to the use of a narrowing valve on the

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No. 34 part 2, April 2022, pp. 316-330

P- ISSN: 2220-5381
E- ISSN: 2710-1096

thrust tube, and in both cases there will be wasted energy , this common situation presents an opportunity to reduce energy requirements by using control methods as a variable speed drive [3].

The pumping system in the Faw depot was selected as a turbine pumping system (variable speed).

1.1 Pumping Plant Efficiency

An irrigation plant has three major components :

1. a power unit.
2. a pump drive or gear head.
3. a pump.

When the power source is electrical energy, the pump motor is directly connected to the pump through a coupling without the need for a gear box, as is the case with turbine engines that depend on fuel or steam as a source of energy.

1.2 Performance Standards

Ther are two common methods of determining the efficiency of pumping plant. One is to measure the efficiency of each component of the plant (motor, shaft and pump). Once the efficiencies of the component are known the overall efficiency is easily calculated. This required specialist equipment and considerable expertise.

Another method is to calculate the load on the motor or engine and the measure how much fuel is used by the power unite . The fuel usage can then be compare to standard.

2. Calculation:

2.1 Calculating Horsepower

Horsepower is a measure of the amount of energy necessary for the work of the equipment. To determine the horsepower of a water pump, the following balls must be known.

1- The flow rate of the fluid.

2- Total dynamic fluid column. total dynamic head (TDH).

Open Access
No. 34 part 2, April 2022, pp. 316-330

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Theoretically, the required power of a water pump is known as water horsepower (whp), which can be calculated according to equation No. (1) : (1)

$$whp = \frac{Q*TDH}{3,960} \qquad \ldots\ldots\ldots\ldots 1$$

TDH = total dynamic head (ft)

Q = flow rate (gpm)

Practically speaking, there is no equipment that works at 100% efficiency, so the horsepower coming out of the equipment is higher than that calculated by equation No. (1), which is referred to as brake horsepower (bhp), and it can be calculated according to equation No. (2).

$$bhp = \frac{whp}{\text{pumping plant efficiency}} \quad \ldots 2$$

2.2 Total Dynamic Head (TDH)

TDH can be considered as the total load applied to the pump and is usually expressed in units of length (ft), where it is known that the unit pressure

TDH can be calculated by equation No. (3).

TDH = (static head) + (friction loss)+ (operating pressure) +(elevation change) …….3[2].

(static head): the vertical distance between the fluid level at the receiving point and the pump thrust tube[3], and it can be illustrated by Figure (1).

Friction losses: These are the pressure losses caused by the fluid friction with the pipe wall and the connecting connections attached to it [2], and they can be illustrated in Figure (2).

Operating pressure: It is the value of the pressure generated by the pump to drive the fluid, and by the above calculations, it is converted to the equivalent of a liquid column, where its value for water is 1 psi = 2.31 ft

Elevation change: It represents the sum of the change in level between the pump level and the thrust point at the end of the thrust pipe, up or down [2].

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No. 34 part 2, April 2022, pp. 316-330

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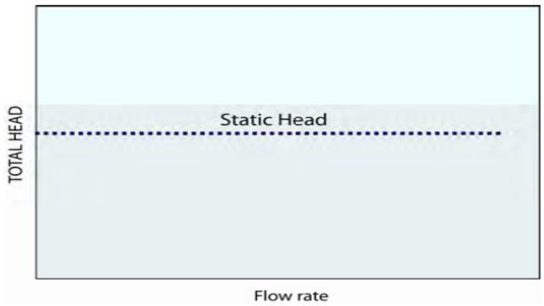

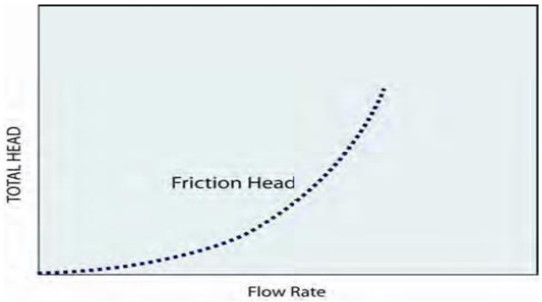

Fig. (1): Static head **Fig. (2): Friction head**

In general, the system curve is by combining the two schemes, which is according to Figure (3) [3].

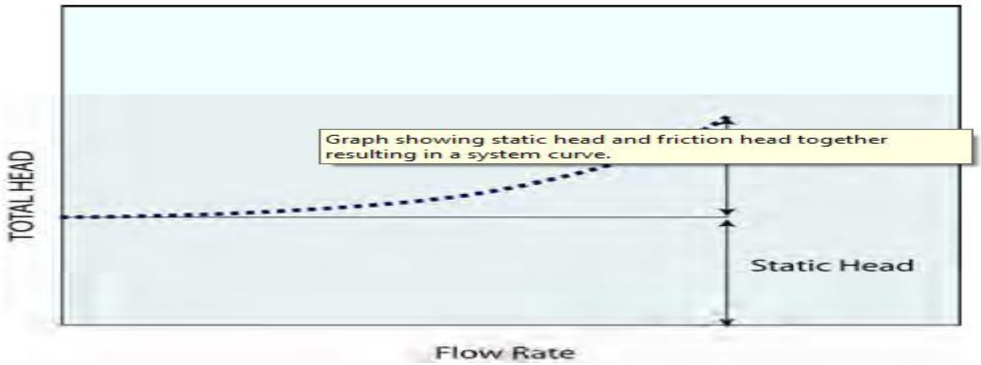

Fig. (3): system curve

Usually several pump charts which represent NPSHR, system curvr, hp & efficiency are collected in one diagram called (pump performance curve), which can be represented by Figure (4).

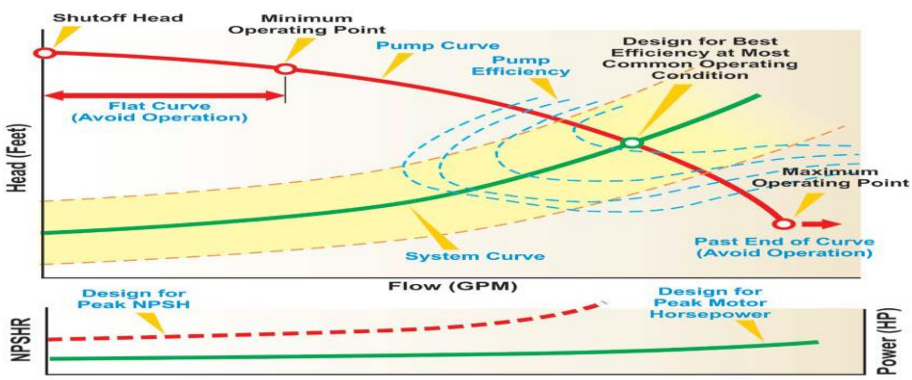

Fig. (4): Pump Performance Curve [4]

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P- ISSN: 2220-5381
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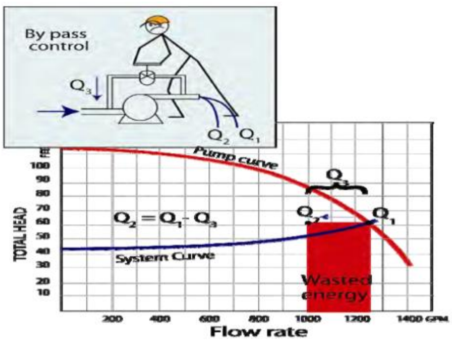
It is clear from the diagram a point for the optimum performance of the pump, which represents the meeting point of SYSTEM CURVE and PUMP CURVE, and that any deviation, whether to the right or left, will lead to problems with the pump and energy loss.

Pumps that operate at a constant speed, usually driven by an electric motor, are designed on the basis of maximum load in terms of flow rate and pressure, but in practice often, especially at the beginning of pumping, and when the pipe is empty, the pressure losses due to friction will be small and therefore the liquid column The required will be less than the specified value, and this is reflected in the consumed power, which is evident by increasing the value of the electric current to the pump motor, and thus requires maintaining the operating pressure of the pump by placing a control valve that tightens the outlet of the liquid and sometimes when the required flow rate is less than the pump's power, it The surplus is rotated to the point of withdrawal, and in both cases there will be a loss of energy, as shown in Figures (5) & (6).

Most existing systems requiring a control method us by pass lines, throttling valve , multiple pumps or pump speed adjustment . Figures (5) & (6) illustrate common control method including variable speed and the potential energy saving. Often changing the pump's speed is the most officiant method of control when a pump's speed is reduces, less energy is used by the pumps power unit and therefore less energy needs to be disported or bypassed.



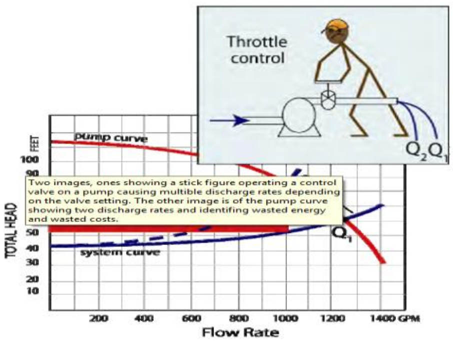


Fig. (5): Bypass control energy use **Fig. (6): Throttle control energy use**

It is known that the pump speed is an indication of the rotation of the pump shaft, which in turn is associated with the glad tidings. The shaft is connected to the impeller adds

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energy to the water , slowing the rotation of the impeller reduce the energy that is transferred to the water and thereby the power requirement of the pump.

2.3 Relationship of pump's speed with pumping requirements

The pumping requirements are related to the rotational speed of the pump, and the following equations explain this relationship, which is known as (Affinity Laws):

$$\frac{Q1}{Q2} = \frac{W1}{W2} \qquad \frac{H1}{H2} = \frac{W1^2}{W2^2} \qquad \frac{BHP1}{BHP2} = \frac{W1^3}{W2^3} \ldots\ldots\ldots\ldots\ldots.4$$

Where:

Q = flow rate

H = head or pressure

BHP = brake horsepower (hp)

W = rotational shaft speed (rpm)

Figure (7) demonstrate how the pump curve change with shaft speed .As the rotational shaft speed (and thus the pump impeller) changes, the pump curve shifts accordingly

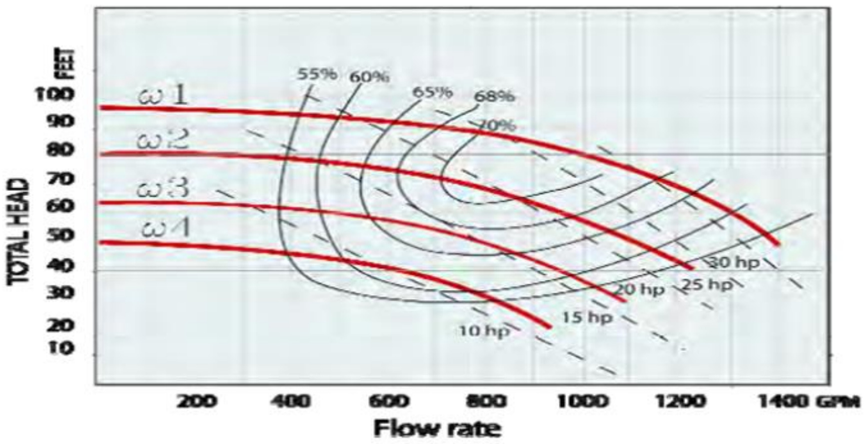

Fig. (7): Pump curve change with shaft speed

It is clear from the (Affinity law) and Figure (7) that the change in the pump speed greatly affects the power required to work the pump, so decreasing the speed leads to a decrease in the energy required in this case . When the pressure required from the pump is mainly to overcome the pressure losses caused by friction, reducing the pump speed will make the operating point on the system curve (system) in line with the efficiency curve and allow the system to operate at several speeds near the highest possible efficiency of the

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No. 34 part 2, April 2022, pp. 316-330

P- ISSN: 2220-5381
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pump with flexibility to control the flow rate and pressure and save Energy as shown in Figure (8).

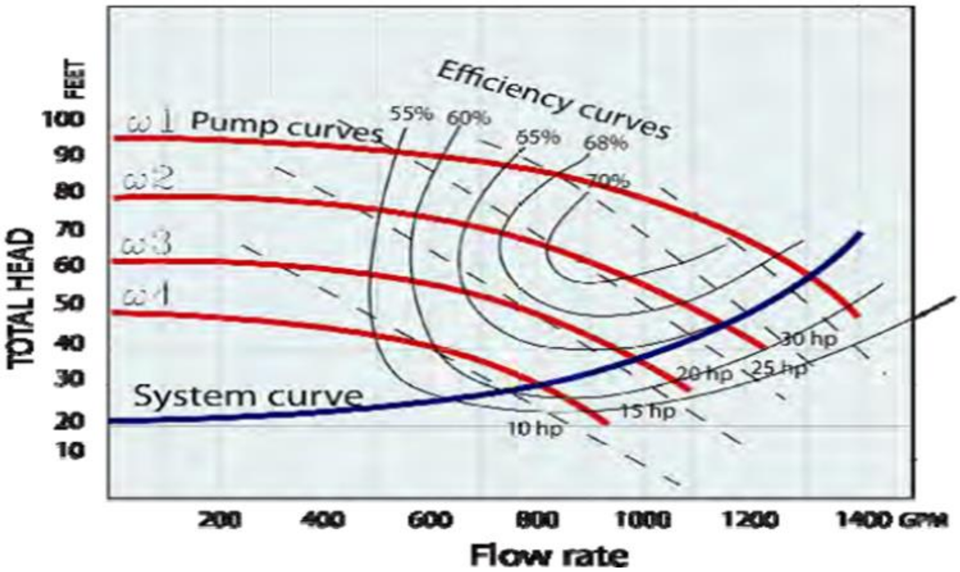
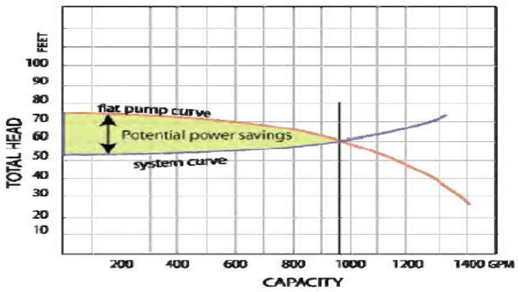


Fig. (8): System curve parallel with efficiency curve

Also, the shape of the pump performance curve has an effect on the amount of potential energy conservation in the pump. The greater the bending amount in the curve, the greater the amount of potential energy conservation in the pump, as shown in Figures (9) and (10) [3].



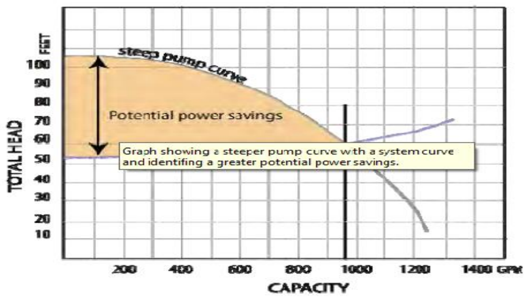


Fig. (9): potential saving flat pump curve **Fig. (10): potential saving steept pump curve**

2.4 Pumping methods for multi-pump system

When we have more than one pump in the system, there are two ways to connect the pumps:

Series connection: In this method, the pump is discharge to the second pump. This method is used when pressure losses due to friction are high, and therefore the need for

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No. 34 part 2, April 2022, pp. 316-330

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high pressures to overcome is difficult to achieve using one pump for the same flow rate. Theoretically, when pumping in series, the pressure achieved from the second pump is twice the pressure achieved from the first pump, but in practice there are some deviations, as Figure (11) indicates, where point No. (2) represents the pressure achieved from the second pump theoretically, but in practice point No. (3) for the same flow rate, while point No. (1) represents pumping using one pump.

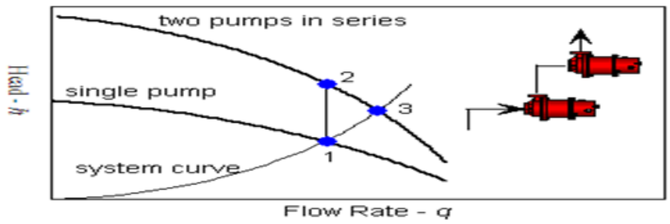

Fig. (11): Series pumps system

Sometimes it is possible to compensate for the use of several pumps in a series by using one multistage pump, but this will be uneconomical if there is a need to gradually increase the pressure depending on the increase in the flow rate.

2.5 Parallel connection:

In this connection, the achieved pressure is the same for each pump with an increase in the flow rate, which can be illustrated in Figure (12), where in theory it is possible to obtain twice the amount obtained with two pumps point (2), but in practice point No. (3) is obtained on the pump performance curve, meaning that the flow rate at point (3) will be half the value for each pump, while the pressure is the same for the two pumps.

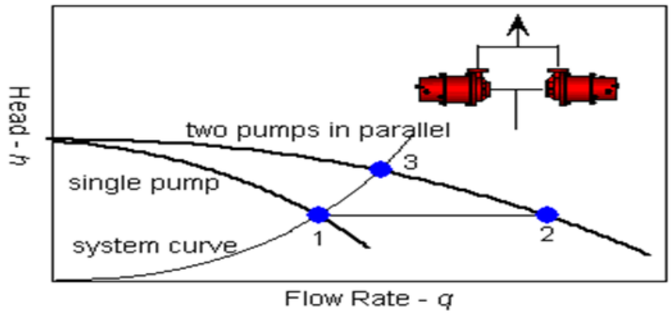

Fig. (12): parallel pump system

Open Access
No. 34 part 2, April 2022, pp. 316-330

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E- ISSN: 2710-1096

Operating two pumps in parallel will have an economic return in terms of energy conservation and maintenance cost from the work of one pump with the same flow rate and pressure, in addition to the operational flexibility to reach several rates of flow and according to need and the use of pumps that are less in size than using one pump

In general, the benefits of pumping using the parallel connection method can be summarized in the following points

- For any given thrust pressure, the flow rate of parallel pumps is multiplied by the number of operating pumps
- The system flow rate is determined by the intersection of the system curve and the performance curve of parallel pumps.
- Pumps with different hydraulic properties can be run in parallel with a common thrust pressure.
- The use of parallel pumps can be beneficial in terms of cost and transportation and installation work.
- Takes less space in the equipment room (especially if using an in-line pump that may be stacked).
- Required capacity will be less.
- Provides more flexibility in circulation at an acceptable rate for each pump compared to if it were one pump with the same total power.
- Provides backup pumps by increasing pump power if necessary [5].

2.6 Energy Effectiveness

The use of a parallel pumping system is the key to reducing the cost of energy use because the pumps will not operate at full capacity in most cases. In order to reach the best number of pumps that can be used, it requires calculating the effect of Energy Effectiveness (gpm/kW) for each pump, then choosing one pump or several pumps depending on the amount of power. Energy Effectiveness can be calculated using the equation no (5).

$$\frac{\text{gpm}}{\text{KW}} = 5{,}310 * Effp * \frac{Effd}{H} \dots\dots\dots\dots\dots\dots.5$$

Open Access
No. 34 part 2, April 2022, pp. 316-330

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Where:

$\frac{\text{gpm}}{\text{KW}}$: Energy Effectiveness

$Effp$: Pump Efficiency

$Effd$: Drive Efficiency (motor or any variable speed driver)

H : Head developed by pump (foot)

From Equation No. (5) it is clear that Energy Effectiveness for each pump increases with an increase in the flow rate (for pumps with a specific speed) and is less for large pumps for the same flow rate. To determine the value of Energy Effectiveness when pumping in parallel, the following must be taken into account:

1. Calculation of gpm/kW vs. Flow Rate curve for each pump and group of pumps.
2. Operate as few pumps as possible to achieve the required flow rate.
3. Choosing the highest achievable Energy Effectiveness [6].

3. <u>Turbo pumps in Faw oil depot</u>

Based on the above, it is possible to understand a mechanism to benefit from the turbo pumps in the Faw oil depot, where the specifications of the four additional pumps will be adopted as an example of the main pumping system in the depot

The system consists of four variable speed turbo pumps connected in parallel to a 48” diameter pipe.

The specifications of the pumps were approved based on the ((system curve) of the third marine pipe and according to the design capacity of the pipe, which is shown in Figure (13).

Open Access
No. 34 part 2, April 2022, pp. 316-330

P- ISSN: 2220-5381
E- ISSN: 2710-1096

Please find here below the curve that has been obtained considering the following points:

Flowrate (m3/h)	Required Head (m)
15900	738
14500	619
13000	505
10000	305
7000	150
4000	45

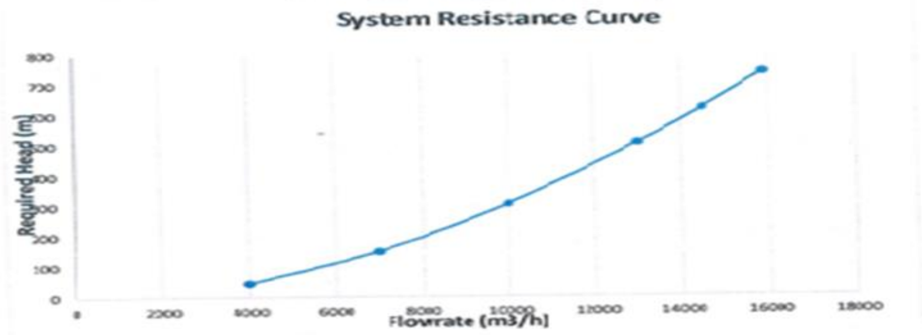

Fig. (13): System curve for sea line No. 3

Receiving pressure has been adopted in the floating platforms (3.5 - 1.5 BARA).

The maximum pumping capacity is 5420M3/H for each pump.

- On this basis, the pumps were manufactured and scheme No. (14) for the pump was approved.

Open Access
No. 34 part 2, April 2022, pp. 316-330

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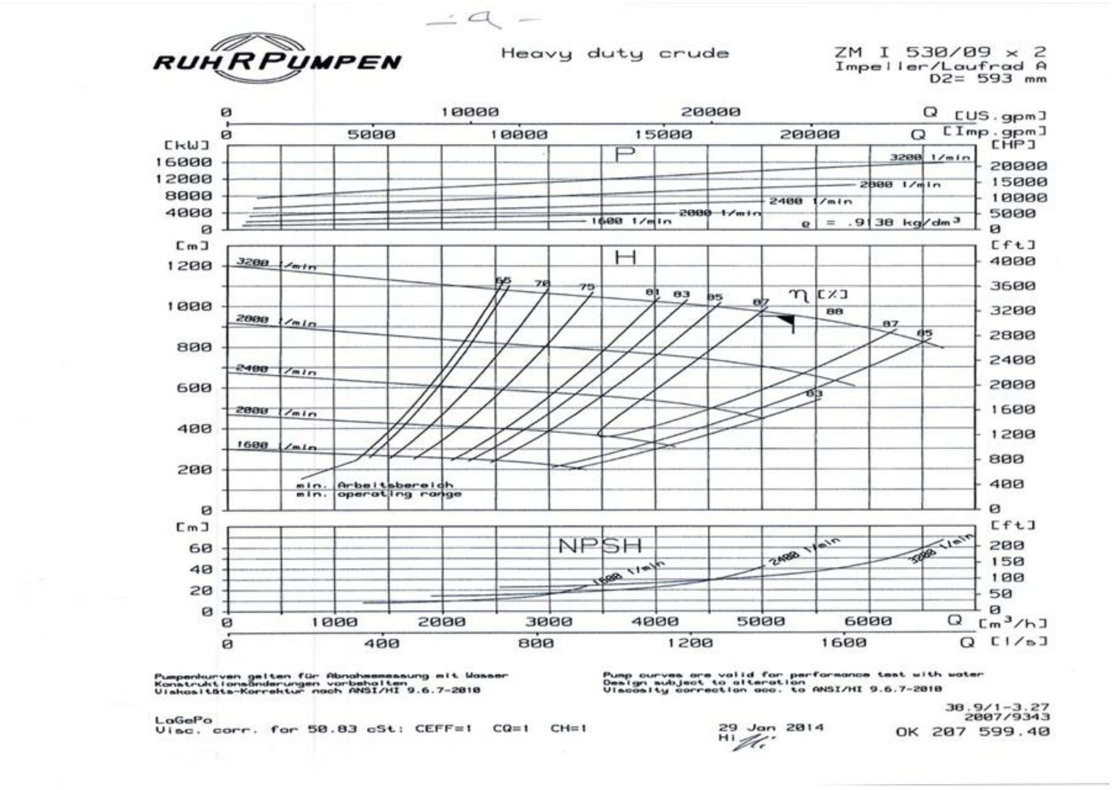

Fig. (14): Single pump performance curve

The required flow rate depends on the type of each tanker and as shown in Table (1).

Table (1) Loading rate of tankers

Vessel type	Loading Rate		Booster Pumps	Export Pumps
	%	M3/h	number	number
Aframax	10	800	1	n/a
	100	8000	1	2
	50	4000	1	n/a
Suezmax	10	1200	1	Nla
	100	12000	2	3
	50	6000	1	n/a
VLCC	10	1720	1	n/a
	100	17200	3	4
	50	8600	1	2

As for the pressures achieved by the pumps and for each flow rate, it depends on the number of pumps needed. According to the operating philosophy, the flow rate and the

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No. 34 part 2, April 2022, pp. 316-330

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appropriate pressure for each rate are increased by increasing the turbine speed and thus the pump speed and according to the number of pumps that will enter the work as shown in Table(2) .

Table (2) The number of pumps required for each flow rate

Oil export flow rate m^3/h	No. of required pumps
0-3000	1
3000 t0 6000	2
More than 6000	3

Where there will be a uniform speed for all pumps operating simultaneously and for each flow rate, as shown in Figure (15).

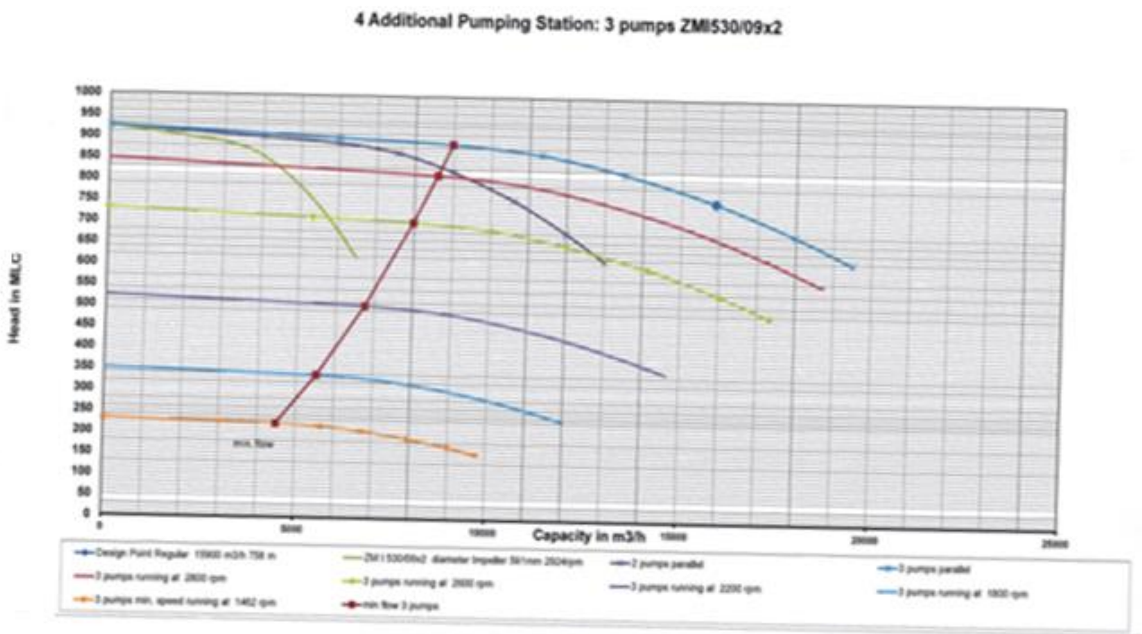

Fig. (15): The performance curve of the pump group in the FAw depot

By the speed chart of the pump (Multi - Speed Performance Curve) and (Pump Performance Datasheet), the consumed capacity when operating more than one pump for the same flow rate is less than if one or two pumps were operated Figure (16) [7].

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No. 34 part 2, April 2022, pp. 316-330

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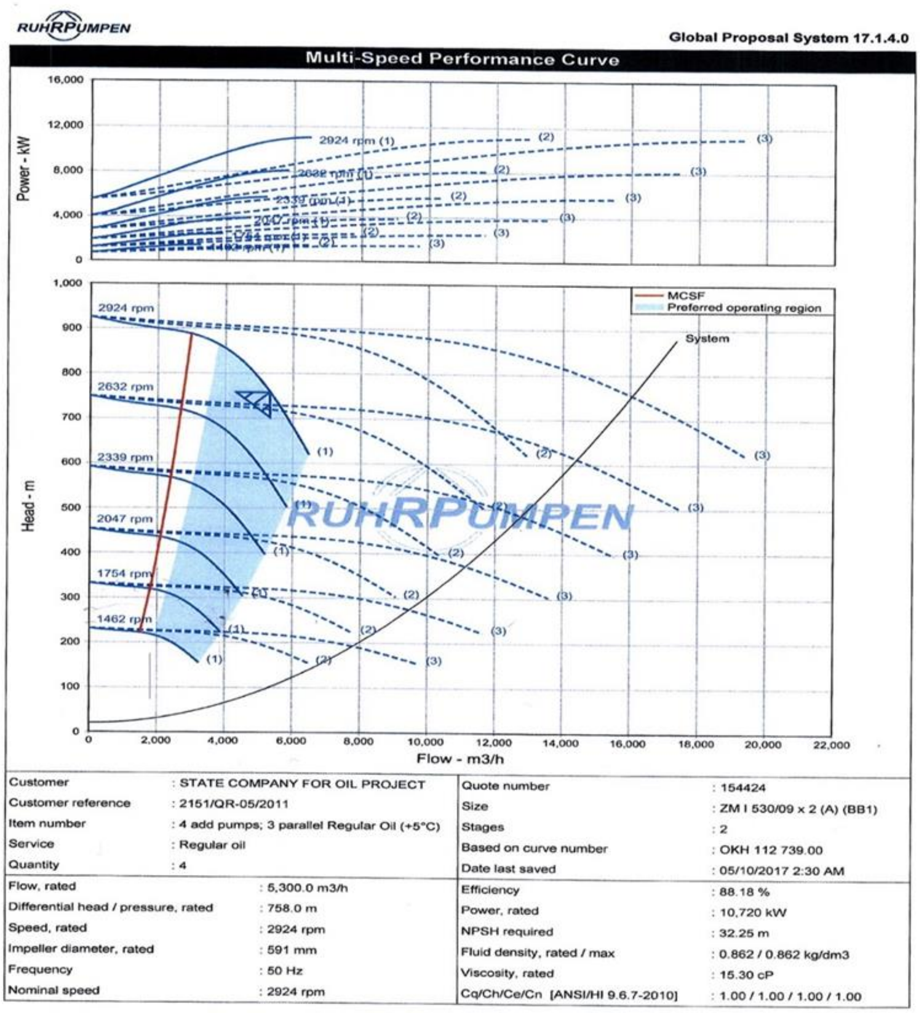

Fig. (16): Multi speed performance curve

4. Conclusions

1. The turbo pumps in the FAW DEPOT where the available data conform to the required technical specifications.
2. There is operational flexibility for the turbine pumps of the Faw oil depot to control the flow rate and pressure according to the pumping requirements.
3. 3-The system of using multi-speed pumps is more useful to control pumping rates without energy loss.
4. When pumping in a parallel system, it is better to run more than one pump instead of running the pump at maximum power.
5. The number of pumps required in the parallel system is calculated after calculating the energy expended for the pumping process.

Open Access
No. 34 part 2, April 2022, pp. 316-330

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