Benha Faculty of Engineering
Mechanical Department
Spec*: Pumps and compressors*
Date: 24/ 1 /2016

Written Examination
Msc. / Diploma: *Dip*.
Subject:
Code: *7434*

Time: Three Hours ***Attempt all questions***

Question 1

Q1-1 Answer the following questions to check your understanding of pump types.

1- A pump is any device that:
   a. Takes energy from fluid motion or position.
   b. Moves a compressible fluid.
   c. Developed pressure.
   d. Moves a fluid from one place to another. (•)

2- All industrial liquid pumps are:
   a. Reciprocating or rotary.
   b. Positive displacement or dynamic. (•)
   c. Centrifugal and axial.
   d. Variable or fixed volume.

3- As a general rule, if you find a running but non-pumping pump:
   a. Shut it down immediately. (•)
   b. Open the intake valve.
   c. Reverse rotation direction.
   After (•)
   d. Vent it and keep it cool.

4- A ram pump is like a piston pump except the ram:
   a. Is operated by air pressure instead of a crank. (•)
   b. Includes inlets and outlets ports.
   c. Rotates, while a position reciprocates.
   d. Is sealed by stationary cylinder rings.

5- Slippage in rotary pump is leakage:
   a. Past the valves.
   b. Internally from outlet to inlet.
   c. Through shaft seals for lubrication.
   d. Around sealing rings. (•)

6- The theoretical volume pumped by a gear pump:
   a. Varies with pressure.
   b. Depend on volume between gear teeth. (•)
   c. Increases with more viscous fluids.
   d. Is adjustable by varying eccentricity.

7- Flexible impeller pumps operate similarity to:
   a. Vane pumps. (•)
   b. Diaphragm pumps.
   c. Axial pumps.
   d. Gear pumps.

8- The most common type of a dynamic pump is the:
   a. Mixed flow pump.
   b. Multi-stage pump.
   c. Single entry centrifugal pump. (•)
   d. Double – acting diaphragm pump.

9- The blades in an axial flow pump:
   a. Cannot produce high flow rates.
   b. Are enclosed between covers.
   c. Curve to move fluid parallel to the shaft. (•)
   d. Rotate the fluid to fling it outward.

Q1-2 Explain the pump cavitation, what are signs of pump cavitation and discuss its influence upon runner-dynamic machines?

The term cavitation refers to condition within the pump where, owing to a local pressure drop, cavities filled with water vapor are formed; these cavities collapse as soon as the vapor bubbles reach regions of higher pressure on their way through the pump.

Noise and vibration.
Pulsation of discharge pressure.
Vane pitting.
Drop in head & efficiency.
Drop of discharge.

Q1-3 A pumping installation to be designed for forcing oil 1.3x105 tons/month through a 135 km pipe line, 200 mm diameter and specific gravity of oil is 0.95, dynamic viscosity 0.0175 kg/m.s and the friction coefficient of pipe line is $F = 0.375\ Re^{-0.25}$, the pressure in the pipe line should not exceed 16 bar, when the pump run at a speed of 1500 r.p.m with A.C motor at frequency 60Hz and efficiency is 95%.

Calculate:

i) The least number of stations,

ii) Sketch diagram line for this system,

iii) The distance between any two stations,

iv) The least number of pumps per station,

- If (η_h = 85%, η_m = 94%, η_v = 98%, where $\eta_o = 1 / [1+(10.89/Ns_{(m,hp)}^{1.29})]$)

vi) The total Electric power required for these stations,

vii) The safe suction pressure that it guarantees the pump operation to be cavitation free.

EX (5)

Given:-

$\dot{m} = 1.3 * 10^5$ ton/month

$L = 135$ km

$D = 0.2$ m

S.G = 0.95

$\mu = 0.0175$ kg/m.s

$f = 0.375 R^{-0.25}$

Pressure in the pipe Line should not exceed 16 bar

$N = 1500$ rpm with AC motor $f = 50$ Hz $\eta_m = 0.96$

Req:-

① the least noumber of station

② the distance betn any two station

③ the least number of pumps per station

If $\eta_h = 0.85$, $\eta_m = 0.94$, $\eta_v = 0.98$ where $\eta_o = 1/[1+(10.89/Ns^{1.333})]$

OR ($\eta_o = 0.75$ and $Ns_{mp} = 36$

④ The total power required for these stations

⑤ the safe suction pressure that it guarantees the pump operation to be Cavitation free.

Sol:- Solution

$$\dot{m} = \frac{1.3*10^5*10^3}{30*24*3600} = \frac{13*10^7}{2592000} = 50.15 \text{ Kg/Sec}$$

$$Q = \frac{\dot{m}}{\rho_{oil}} = \frac{50.15}{950} = 0.05279 \text{ m}^3/\text{sec}$$

$$Q = A\bar{V} \Rightarrow \bar{V} = \frac{Q}{A} = \frac{0.0527*4}{\pi (0.2)^2}$$

$\bar{V} = 1.68$ m/sec

ثانياً حساب

$$R_e = \frac{\rho V D}{\mu} = \frac{950 * 1.68 * 0.2}{0.0175}$$

$$R_e = 18240$$

$$R_e = 18.24 * 10^{3}$$

$$4f = 0.375 R_e^{-0.25}$$

$$= 0.375 * (18.24 * 10^{3})^{-0.25}$$

$$f = 0.03227$$

ثالثاً Calculate head losses

$$h_f = f \frac{L}{D} \frac{\bar{v}^2}{2g}$$ * neglected mainor losses

$$= 0.03227 * \frac{135 * 10^{3}}{0.2} * \frac{(1.68)^2}{2 * 9.81}$$

$$h_f = 3133.3 \text{ m}$$ ← مقدار ال head losses في خط طوله ١٣٥ كم

فليس من المنطق استخدام طلمبة واحدة من أول الخط حتى نهايته
وبالتالي لابد من اللجوء لعمل محطات.

$$h_f > 16 \text{ bar}$$

$$3133.3 = h_f > 160 \text{ m}$$

$$\therefore \Delta P = \rho g h_f$$

$$= 950 * 9.81 * 3133.3 = 29200789.35 \text{ Pa}$$

$$\Delta P = 292 \text{ bar}$$ هنا هو الضغط المراد للتغلب على head losses

Subject: Date:

P = 16 bar critical على مستعمل — حسابات عدد و مسافة المحطات

[1] أول مطلوب

$$\text{No of station} = \frac{\Delta P_{\text{Total}}}{16}$$

$$\text{No of station} = \frac{292 \text{ bar}}{16 \text{ bar}}$$

$$\text{No of station} = 18.25 \text{ station}$$

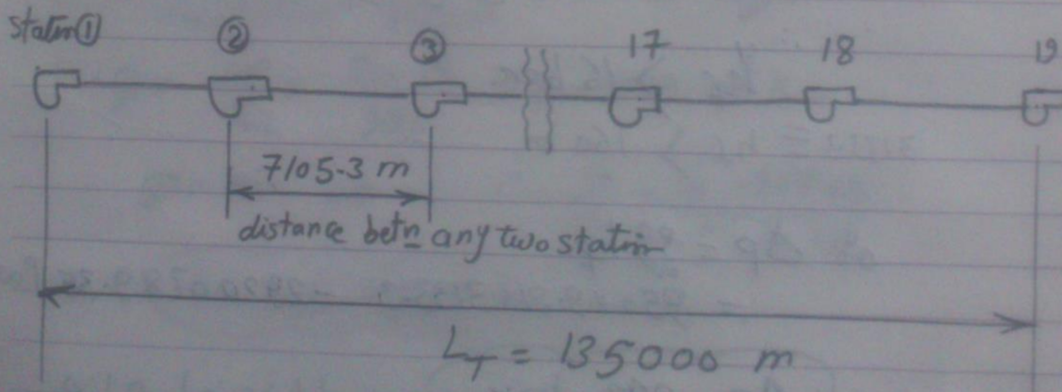
أولاً # $\boxed{\text{No of station} \simeq 19 \text{ station}}$

تقريب على طول ١٣٥كم

ثاني مطلوب [2] distance betn any two station

$$\text{distance} = \frac{L_T}{\text{No of station}} = \frac{135000}{19}$$

$\boxed{\text{distance} = 7105.3 \text{ m}}$ # ثانيًا



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Subject :

ثالثاً the least number of pumps per station

* least no of pumps per station [one pump axial Centrifugal pump multi-stage (3 stage) 20 bar per station
→ Low cost
OR
* using 2 pump one in operation and other pump is stand by but → high cost

④ رابعاً total power required for these station

* أولاً نتم حساب [Power required] لمحطة واحدة

$Q = 0.05279$ Kg/sec

$\Delta p|_{max} = 16$ bar

hydraulic power = $\gamma Q H = \Delta p Q$

so oil power = $\Delta p Q$

$= 16 \times 10^5 * 0.05279$

oil power = 84464 watt

$$\text{Electric power} = \frac{\text{oil power}}{\eta_o} = \frac{84464}{0.75}$$

Electric power = 112618.7 Watt

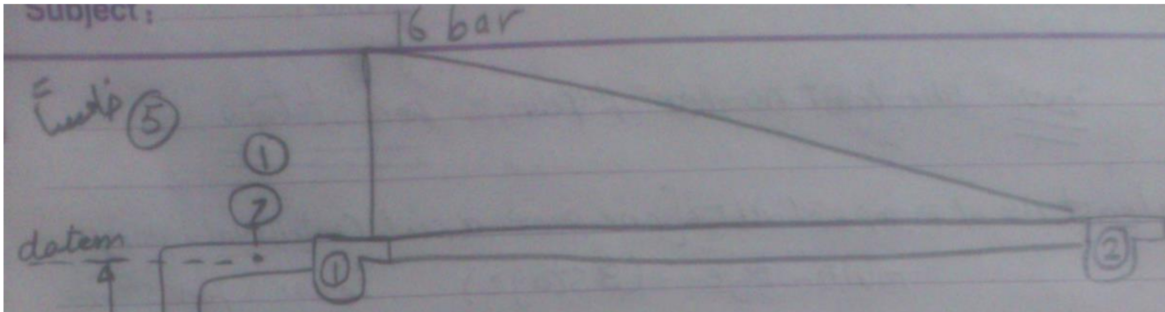
= 112.62 Kwatt / one station / one pump

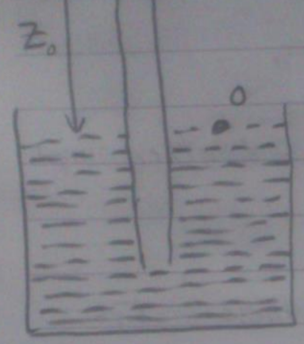
Total Power| one pump per one station = Electric Power| one station * No. of station

Total Power = 112.62 * 19 = 2139.8 Kwatt

ElAtlal

مسألة (5)





Assum $T = 20^\circ C$

from chart found $P_{ve} = 500\ kpa$

شرطا لكي تعمل الطلمبة بدون حدوث Cavitation

① $P_1 > P_{ve}$

② $NPSH_A > NPSH_R$

⊛ $P_{suction\ save} = \rho_o g H_{ms}$ → manometric suction head

$$10 \frac{\rho_w}{\rho_o} = \delta H_p + H_{ms}$$

$$\delta = 2.14\, N_{s_{mp}}^{4/3} * 10^{-4}$$

$$\delta = 2.14 * (36)^{4/3} * 10^{-4} = 0.0254$$

$$10\frac{S_w}{S_o} = \delta H_p + H_{ms}$$

$$10*\frac{1000}{950} = 0.0254*16*10 + H_{ms}$$

$$H_{ms} = 10.526 - 4.064$$

$$\boxed{H_{ms} = 6.462 \text{ m}}$$

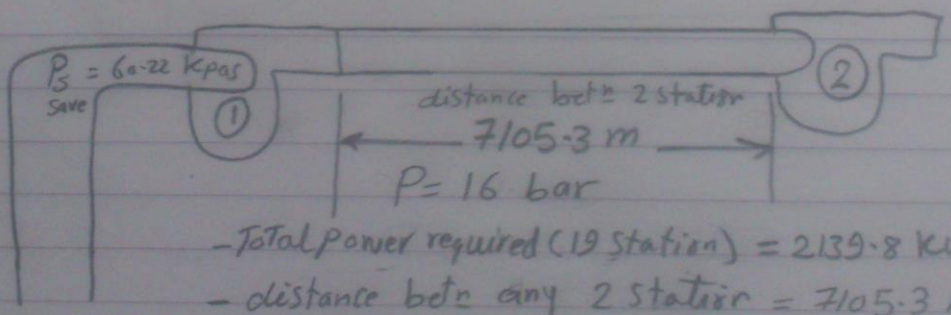
$$P_{suction}{}_{save} = S_o g H_{ms}$$

$$= 950*9.8*6.462$$

$$P_{suction}{}_{save} = 60222.6 \text{ Pas}$$

$$\boxed{P_{suction}{}_{save} = 60.22 \text{ kPas}}$$

all data for stations



- Total Power required (19 station) = 2139.8 Kwatt
- distance bet= any 2 station = 7105.3 m
- $\dot{m}$ transfer along Line = 0.05279 kg/sec
- No of station = 19 station
- No of pump/station : one pump Centrifugal pump multi-stage 3 stage

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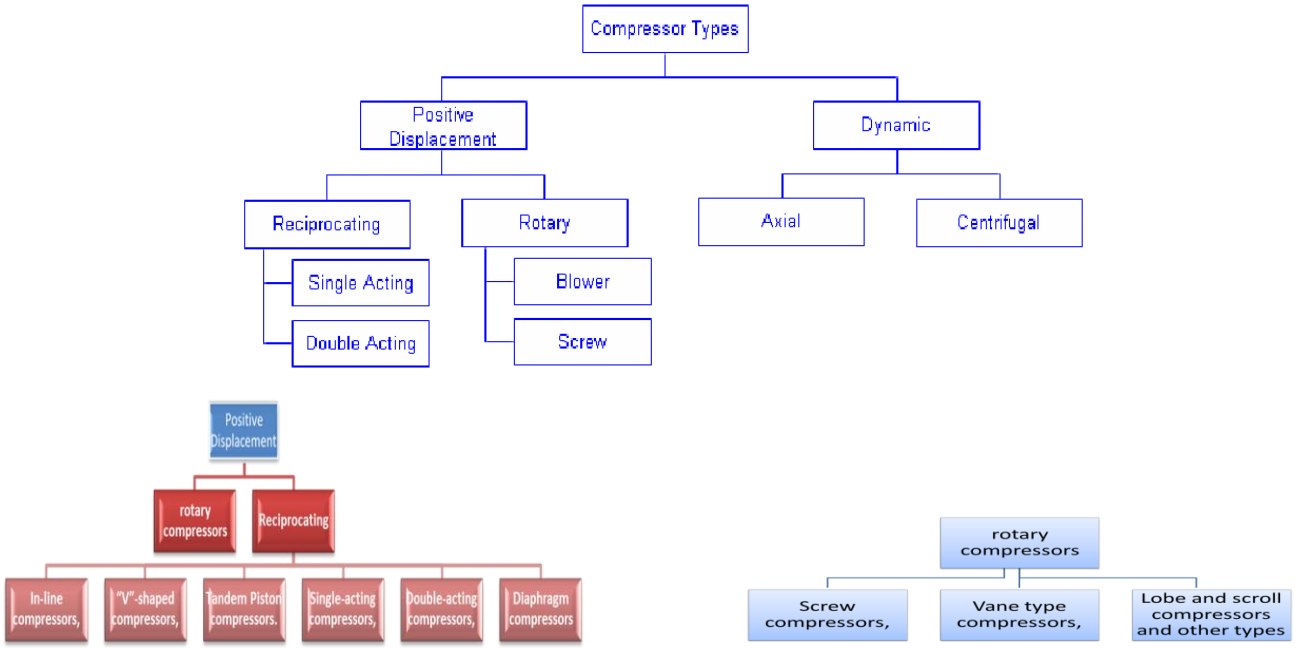
- $P_{suction\ save}$ = 60.22 kpas

Question 2 ***(20 marks)***

Q2-1 Explain with sketch different types of compressors and principle of operation?



Q2-2 What the meaning of: surge, surging effects, preventing the surge, surge point, surge line, stalling and type of stalling?

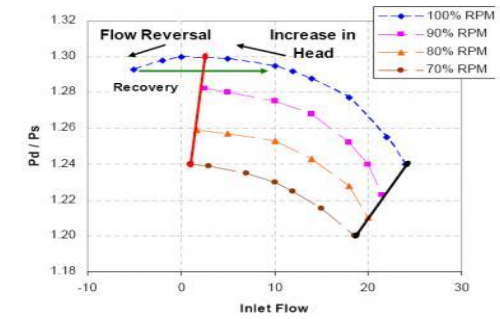
Surging is the complete breakdown of steady flow in the compressor which occurs at low flow rate. Surging takes place when compressor is operated off the design point and it affects the whole machine and this is aerodynamically and mechanically undesirable.

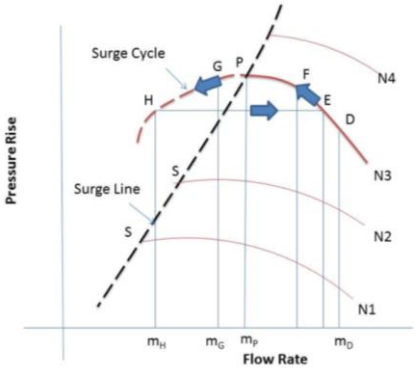
- ✓ surging results in violent fluctuations in discharge pressure.
- ✓ when an electric motor is used as driver surging can cause extreme variation in motor current.
- ✓ symptoms of surging are low gas flow, excessive vibration and banging sound inside compressor

1. to prevent the surging the flow rate of the gas through the compressor must be kept above the minimum stable flow rate or surge point
2. when the demand is low flow rate is maintained by recirculating the portion from discharge to back to compressor.

Surge points are the peak points on the characteristic curves. left of which the pressure generated by the compressor is less than the pipe pressure and these points initiates the surge cycle

Surge line is the line which connects the surge points (S) on each characteristic curve corresponding to different constant speeds. The stable range of operation for the compressor is on the right hand side of the surge line.



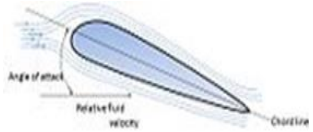


Stalling is the separation of flow from the compressor blade surface

Types of stalling

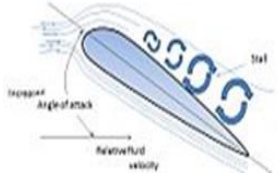
1- positive stalling

At low flow rates the incidence angle or angle of attack increases and due to this there occurs the flow separation on the suction side of the blades



2- negative stalling

the flow separation occurs on the pressure side of the



Question 3 *(20 marks)*

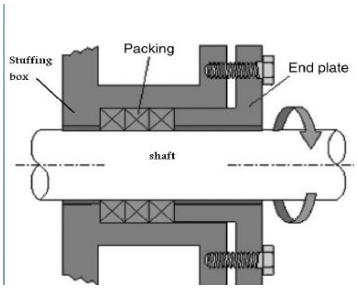
Q3-1 Explain the purpose of lubrication and the lubrication methods in mechanical parts.

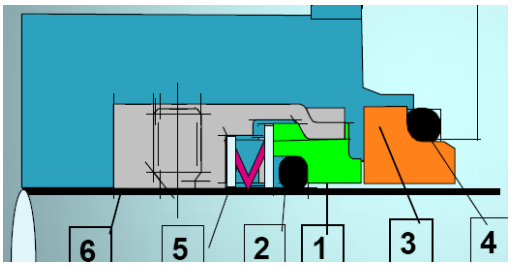
Purpose of lubrication 1)-Keep moving parts apart. 2)-Reduce friction. 3)-Transfer heat 4)-Carry away contaminants & debris. 5)-Protect against wear. 6) - Prevent corrosion.

Lubrication method:1)-Oil Bath Lubrication Oil bath lubrication is widely used for low or medium speeds. The oil level should be at the center of the lowest rolling element. It is desirable to provide a sight gauge so the proper oil level may be maintained. 2)-Splash lubrication With this lubricating method, oil is splashed onto the bearings by gears or a simple rotating disc installed near the bearings. Submerging the bearings in oil is avoided 3)-Circulating Lubrication Circulating lubrication is commonly used for high-speed operation requiring bearing cooling, and for bearings used in high temperatures. As shown in drawing a, oil is supplied by the pipe on the right side, travels through the bearing, and drains out through the pipe on the left. After being cooled in a reservoir, it returns to the bearing through a pump and filter. The oil discharge pipe should be larger than the supply pipe so an excessive amount of oil will not back up in the housing.

Q3-2 What are the different types of seals show with drawing the advantages and disadvantages of each type?

Type of shaft seals 1) - Packing ring. 2) - Mechanical Seal.





1.4) advantage of used packing 1)- This is a simple 2) - low cost, and easy to maintain 3) - Controlled leakage by tighten the gland 1.5)
Disadvantage of used packing 1)- A persistent leakage and loss of product if the shaft surface is not smooth 2)-If the gland is too tightened, the shaft/sleeve gets hot and there can be rapid Wear of the surface 3)-They require constant supervision..

Q3-3 Describe the coupling, coupling types and explain the methods of coupling alignments?

Couplings are mechanical elements that couple two drive elements which enable motion to be transferred from one element to another. The drive elements are normally shafts.

1)– Rigid coupling:-

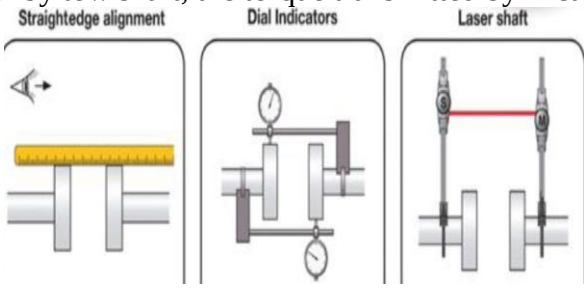
Rigid couplings are mainly used to connect shafts In perfect alignment. The smallest degree of misalignment will cause considerable stress on the coupling

2) - Flexible coupling

Flexible couplings are designed to transmit torque while permitting some radial, axial, and angular misalignment. Flexible couplings can accommodate (damping) angular misalignment up to a few degrees and some parallel misalignment

3)- Clutch Coupling

Clutch used to transmit power by tow shaft, the torque transmitted by friction between disks.



With best wishes
Dr. Mohamed Ramadan Gomaa