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Research Article

Design of Capillary Pump

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Abstract

In this world of faster pace there is the current need to raise research in Go green technologies so there is need to develop self-sustainable systems to fulfill the work as a result there is current need to generate green energy if possible to develop a system which require no external energy source for it's functioning and operation so this Capillary pump is a device which works without electricity when engineered properly. This is the current need for the world it's not only a go green technology it's also automated in another way so we are going for a project on this self-energized and automated system to pump water in fields and into the overhead tanks for domestic purpose it's principle is just capillary action combined with some engineering to make it more effective.

Keywords: *Self-sustainable systems etc.*

Introduction

Capillarity is the property of liquids which results due to the adhesion of liquid molecules to the walls of the container or a tube this results in rise of liquid in it's container.

This raise is assisted with upward suction created by a centrifugal force of rotating tubes by the wind energy. Though it makes a huge equipment of wind mill but it can be compacted when engineered properly the employment of both capillarity and upward suction makes system of pumping without any centrifugal pump so it can be a go green technology.

The capillarity is very high for water raises very high due to adhesion as mercury does not because of it's cohesion the meniscus of mercury is convex in shape while the meniscus of water is concave in shape.

Factors effecting capillarity

Pressure it effects a lot as per my experimental results I found that the water raises up to 40mm in 6 minutes at atmospheric pressure and it raises the same 40mm in 3 minutes when water pressure is increased with paper as the transporting medium this concludes that pressure and capillarity are directly proportional

Area of the capillary medium or tube the diameter of capillary tube must be less for more capillarity this projects that area of capillary medium and capillarity are inversely proportional.

As the upward suction pressure is more it affects capillarity so when suction is high it results in high capillarity.

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Medium for capillarity when the medium is highly porous the capillarity will be more and effective. The medium is more porous high capillarity can be achieved.

Flaw: it is a fact that when capillary tube is cut below the level of water in it can raise the water will not move out but remain adhesive with material walls so we planned to use a suction wind powered suction equipment for successful lifting of water which creates a negative pressure in the delivery pipe.

Areas where engineering is required

- Pipes used for transport of liquid.(according to project water is considered)
- To create some suction so design of effective wind propelled fan.
- Contact volume with water.
- Material at primary contact.
- Equipment to increase water pressure.
- Manufacturing of the pipes used for the capillarity.
- Delivery system for the pumped water at overhead tanks
- To stop the pumping when required.

Uniqueness from recent trends is the compactness and simplicity in engineering

Pipes Used for transportation of liquid

On calculations we got the value of rise in water by capillarity is 5mm

Technical Specifications of pipe

Main outer pipe diameter = 78.2 mm
Main pipe is completely filled with small pipes of diameter=3mm which results in the capillary rise = 5mm
Inner pipe is again divided into chambers each chamber contains 1.5mm of capillary tube section and 1.5 mm thick suction material.

Terminology

P = pressure
v = velocity
g = acceleration due to gravity
(Ro) = Density
Q = discharge rate
h = capillary rise
A = Area
On calculation with capillary action tube diameter we got the rise of 5 mm and we proceeded accordingly for the design of other components

Pump Specifications

1) Supply velocity = 5 ft/sec
2) Pressure in capillary pipe = 4905 N/m^2
3) Suction pressure = 4763.5 N/m^2
4) Discharge rate = 0.00417 m^3/sec
5) Volume of discharge tank = 0.1963 m^3
6) Time taken to fill the tank = 47 sec
7) Vol of feed maintaining tank = 0.393 m^3
8) Height of capillary tube = 3.0 m
9) Height of feed control tank = 0.5 m
10) 10. Height of suction equipment = 0.3 m
11) Pump working principle "Capillary action"

Calculations

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$\rho A_1 V_1 = \rho A_2 V_2$
$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + h_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_2$

Capillary Pipe:

Specifications:

Dia = 3 inch= 0.0762m
Height = 3m
Capillary tubes = 0.003m
No of tubes = 25

Overhead tank Specification:

Dia = 0.5m
Height = 1.5m
Volume = 0.1963m^3

Capillary rise calculations:

$h = \frac{2S\cos\theta}{r\rho g} = \frac{(2)(0.0728)(1)}{(1000)(9.81)(0.003)} = 5\text{mm}$
S = Surface Tension
ρ = Density
r = Radius of capillary

Number of tubes to be placed for capillary action = 645
Suction Equipment:

RPM = 100
V = 0.532 m/s

Stagnation Pressure in capillary Pump:

$P = \rho g h = 1000 * 9.81 * 0.5 = 4905 \frac{N}{m^2}$

Suction pressure calculations:

$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g}$
$V_1 = 0, \quad \rho = 1000, \quad g = 9.81, \quad P_1 = 4095 \frac{N}{m^2}$
$V_2 = 0.532 m/s$, $P_2 =$?

By substituting the above values in the equation
$P_2 = 4763.5 \frac{N}{m^2}$

Delivery rate calculations:

Q = V*A
= 0.00417 m^2/sec

$\frac{dv}{dt} = K$

Integrating on both sides

$\int dv = \int K\, dt$
$V = Kt + C$
At t = 0, V = 0
0 = 0 + C
C =0
At V= 0.1963, Q =0.00417
V = KT
T= 0.1963/0.00417 = 47.004 sec

*RPM is assumed in calculation

*Discharge volume is not changing with time

Description & working of pump

Pump has 3 major sections

A. Pressure maintaining tank.
B. Capillary pipe.
C. Wind powered Suction system.

Pressure maintaining tank it maintains constant pressure and head of 0.5 m in the capillary pipe it's mainly designed to take in the running water from municipal connection and keep feeding the capillary pipe through a constant cross-section connection.

Specifications

1) Height = 0.5 m
2) Diameter = 1 m

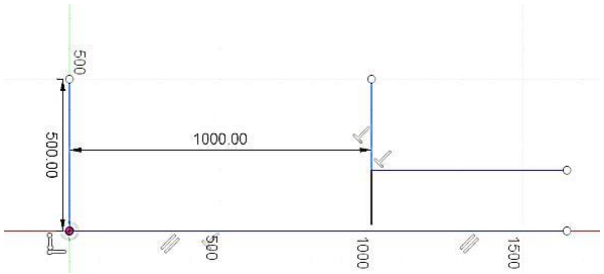


Fig.1 Pressure maintaining and feeding tank

Capillary pipe it is the main component of the capillary pump it carries the capillary tubes along it's area and absorbing material to with-hold the water to fight the accidental negative pressures. It's of 3 meter in height and the first half meter is filled with the water and the capillary tubes of diameter 0.003 m 25 in number are placed of height of 503 mm height and absorbing material of 1.5 mm height and again the remaining 2.5 m height is filled with the capillary tubes of height 300 and 25 in number along the area same is repeated and the number of sets required are 500 placed one above the other to fill the remaining 2.5 m height.

Specifications

1) Diameter of capillary pipe = 0.0762 m
2) Height of capillary pipe = 3 m
3) Diameter of Inner capillary tubes = 0.003 m
4) Number of capillary tube along main pipe = 645
5) Number of sets = 500

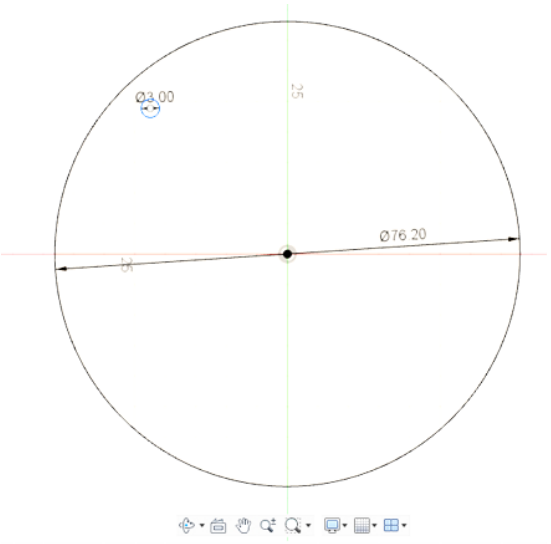


Fig.2 Proof of area to no of capillary pipe

Sets = combination of absorption material and capillary tubes.

Absorption material it is similar to the water filter candle clay or ceramic it holds the water for next capillary set when there is backward suction.

Wind powered suction system it is the main component designed to increase the discharge rate and velocity of water in to the main delivery tank the main 3 inches pipe is assembled with a bearing and a 0.038 m diameter pipe raises up to 0.173 and above it a wind-mill of diameter 0.127 m is provided which is connected with the bevel gears to rotate the 0.038 m diameter pipe about 100 rpm and the wing section emerging from the 0.038 m pipe is 0.1016 in diameter so on calculation the angular velocity of 100 rpm and radial distance of 0.0508 m the linear velocity is 0.532 and on applying energy equation the suction pressure is obtained i.e 4763.5 n/m^2. This delivers the water into tank through the delivery pipe.

Specifications

1) Suction pressure is = 4763.5 N/m^2
2) Delivery rate = 0.00417 m^3/sec
3) Tank is filled in time = 47 sec

Over-head tank it is a simple water holding tank or delivery tank it's height is 1.5 m and diameter is 0.5 m.

Advantages

- No electricity required.

- No energy conversions.
- No complicated designing of motor components and casings.
- No sound of running motor.
- No priming problems.
- No problem of Pump gland & bearing damage due to overheating.
- No problem of Shaft misalignment.
- No problem of Seal ring damage.
- No Issue of Wear ring damage.
- No Impeller damage.

Disadvantages

- Not recommended for high heads unless perfectly and highly engineered.
- Unfit for high viscus fluids.
- A pressure maintaining tank which consumes more space.
- Wind-mill rpm must not go down to below 100 rpm.
- Slow process compared with centrifugal pumps.
- Water height must not go lesser than the 0.5 m in pressure maintaining tank.
- Assumptions while designing may affect the performance.
- Maintaining the pump may be difficult if dust is accumulated in capillary tubes.
- Manufacturing cost of pipe may be high.
- Efficiency of wind suction must be high.

Over-view of work

This pump is designed theoretically based on parameters of the supply of municipal water for domestic purpose the height of the overhead tank is decided by general residential building height. The capillary pumps are not designed till date so no literature review is submitted work is done according to the references given below.

*If the pump is used for agricultural fields with two equipments

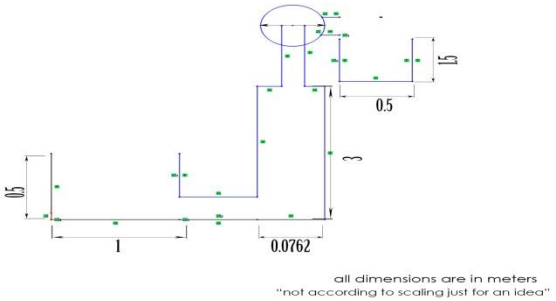
Contact volume with water

The contact volume is of the length of feed tank and width of feed tank and thickness is 3-4 cm can be modified further as per flow requirement and calculation.

Material at primary contact

- Primary contact material is filter candle material as it absorbs the water and delivers through it's delivery chamber.
- The absorption factor of material should not be less than 1
- The candle operates at a pressure of 6-9 bars

Ruff drawing of pump for an idea



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