PH203 : Vacuum Science and Techniques

Calculation of Throughput and Pumping Speed in a Vacuum Chamber

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Introduction

In this project, we will study about throughput and pumping speed and how to calculate them using different parameters. We will deploy a web application interface and write program for their calculation using two different methods i.e. using gas equation and the formula for pumping speed for a diaphragm pump.

Theory

- **Throughput (Q) :** It is the quantity of gas flowing through a pipe per unit time. (Also sometimes, referred to as the product of pumping speed and the inlet pressure).
  Unit: **$Pa.m^3/s = W$**
  Also, if **Q > 200D => Turbulent** and if **Q > 100D => Laminar**

- **Pumping Speed (Sp) :** The volume of gas per unit time (dV/dt) which the pumping device removes from the system at the pressure existing at the inlet of the pump.
  Unit: **litres/s, m^3/hr**

Calculations

- **Using Gas Equation**

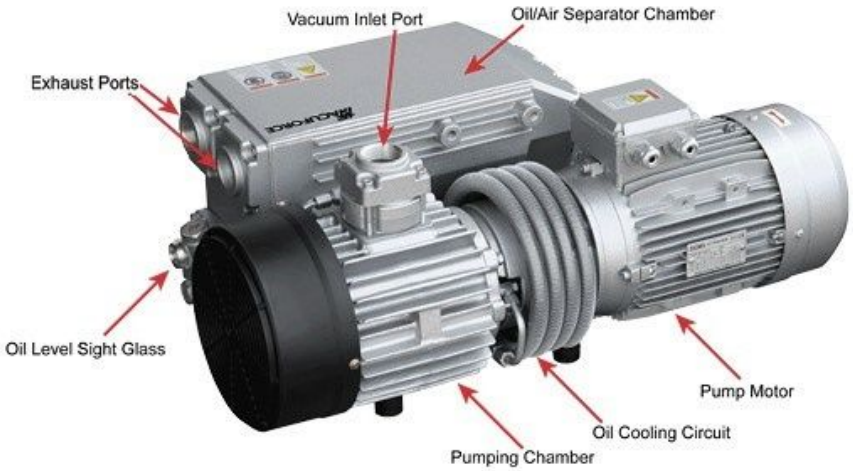
  Throughput (Q) = P * (d(V)/d(t))

  => **Q = (dN/dt) * (R.T)**

  Pumping Speed (S) = Q / P

  where,

  n = Moles of Gas
  P = Pressure
  T = Temperature
  t = Time



Calculations

- **For a Suction Chamber**

  Throughput(Q) = $q_p V$

  => **$Q = n * (V_s * p_{in} - V_{D.S} * P_{out})$**

  Pumping Speed (S) = Q / p_{in}

  where,

  N = Rotational Speed
  V_s = Suction Chamber Volume
  P_{in} = Input Pressure
  $V_{D.S}$ = Dead Space Volume
  P_{out} = Output Volume

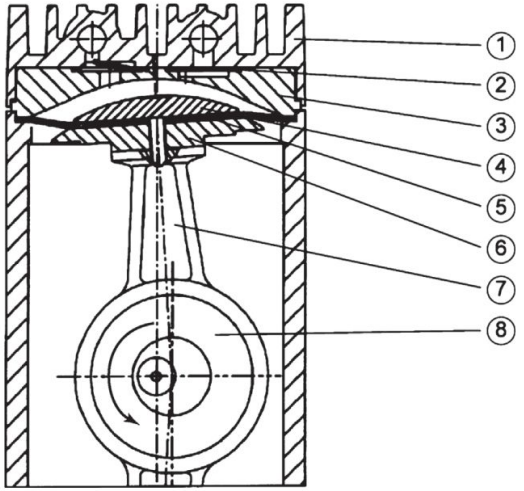


Figure 7.3 Diagram of a diaphragm pump stage: ① housing, ② valves, ③ head cover, ④ diaphragm clamping disk, ⑤ diaphragm, ⑥ diaphragm supporting disk, ⑦ connecting rod, ⑧ eccentric rotor (crank shaft).

A labelled diagram of a Diaphragm Pump

Code Analysis

- **For Gas Equation**

```
var throughput = (inputs[0].value * 8.314 * inputs[2].value) /
inputs[3].value;
var pumpingSpeed = throughput / inputs[1].value;
```

where,

input[0] = Moles of gas
input[1] = Pressure
input[2] = Temperature
input[3] = Time

Code Analysis

- **For Suction Chamber**

```
var throughput = inputs[0].value * (inputs[4].value * inputs[1].value - inputs[3].value * inputs[2].value)
var pumpingSpeed = throughput / inputs[1].value
```

where,

input[0] = Rotational Speed
input[1] = Input Pressure
input[2] = Output Pressure
input[3] = Dead Space Volume
input[4] = Suction Chamber Volume

Link of code and deployed website

- **Link of code uploaded on Google Drive**
  https://drive.google.com/drive/folders/1ynyAipDhC0C9HRJ4Wz8475ZVgr4qcXkN

- **Link of website deployed on Netlify**
  https://ph203projectcs73-49-32.netlify.app/

Screenshots
of the website made

PH203 PROJECT

HOME | GAS EQUATION | SUCTION CHAMBER | ABOUT US

Calculation of Pumping Speed and Throughput in a Vacuum Chamber

USING GAS EQUATION :-

Qty of gas 'n' :
(in mol)

Pressure P :
(in Pa)

USING GAS EQUATION :-

Qty of gas 'n' :
(in mol)

2

Pressure P :
(in Pa)

10000

Temperature T :
(in K)

300

Time t :
(in s)

2

CALCULATE

Throughput (Q) : 2494.2 W
Pumping Speed (S_p) : 249.42 l/s

FOR SUCTION CHAMBER CONNECTED TO A DIAPHRAGM PUMP :-

Input Pressure p_{in} :
(in Pa)

3

Output Pressure p_{out} :
(in Pa)

2

Suction Chamber Volume V_S :
(in m^3)

2

Dead Space Volume $V_{D.S.}$:
(in m^3)

1

Rotational Speed n :
(in rpm)

2

CALCULATE

Throughput (Q) : **8 W**

Pumping Speed (S_p) : **2666.6666666666665 l/s**

Team Members :

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- Manjul Bamrara (1901CS32)

Conclusion

In this project, we studied about throughput and pumping speed and how to calculate them using different parameters. We also created a web application interface for calculation of throughput and pumping speed in a vacuum chamber. Many such softwares can be created for the ease of engineers that are useful in many cases.

So, at the end, we achieved our goal and wrote a program for the calculation of throughput and pumping speed successfully.

Thank You!